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PARASITOLOGY

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BRITISH MUSEUM Z D NATURAL HISTORY

THE TREMATODE GENUS *STEPHANOCHASMUS* LOOSS IN THE GULF OF MEXICO.

BY HENRY S. PRATT,
Haverford College, Haverford, Pa.

(With Plate XIII.)

Two species of the genus *Stephanochasmus* have been found in the fishes examined for parasites at the station of the Carnegie Institution of Washington, situated on the island of Tortugas in the Gulf of Mexico. These are *S. casus* Linton and *S. sentus* Linton. The anatomy of these worms contains several novel and interesting features, and that of the first named will be described here in detail.

S. casus lives in the rectum of two common fishes, the gray snapper (*Lutianus griseus*) and the yellow tail (*Ocyurus chrysurus*), where it was found by both Linton (1910) and myself. The length of the eleven specimens in my collection ranges between 2 mm. and 6 mm. (Fig. 1). The body is soft and contractile and is consequently much broader at some times than at others. The breadth of the specimen figured, which is somewhat contracted, is 1 mm. The breadth of a fully extended animal of the same length is about 0·7 mm.

The living worm is usually deep red in colour, in consequence of the blood contained in the capacious intestine. In the various stages of contraction of the different individuals the organs may show a somewhat different arrangement. The testes and ovary, for instance, are pressed closely against one another when the body is much contracted (Fig. 2); but when it is extended these organs may be separated from one another by a considerable distance. The body is oval in cross section (Fig. 3). It is covered with the large spines characteristic of the genus, the number encircling the mouth being 36, arranged in two rows (Fig. 1). These rows are not interrupted ventrally, as is the case in certain species of the genus. All the spines are very easily lost by maceration.

The two suckers are of rather small size, the oral sucker (Fig. 1, 27), which is terminal in position, having a diameter, in the specimen figured, of 0·29 mm. and the acetabulum (Fig. 1, 1) one of 0·49 mm.

A pair of groups of pigment granules (Fig. 1, 32) is present in the dorsal body wall a short distance behind the pharynx, which, as Looss (1901) has shown, are the remains of the cercarian eyes and characterize most of the species of the genus. The granules composing each eye are very distinct and number from 20 to about 50. In much contracted specimens they are often crowded closely together or form a single mass, while in extended worms they are more or less separated from one another.

The mouth is cup-shaped, having a characteristic semi-circular outline, and opens into a long prepharynx (Fig. 1, 33) which in the specimen figured is 0·65 mm. long. The hinder end forms a circular fold around the anterior end of the pharynx (17), which is a large piriform organ (31) 0·33 mm. long and 0·22 mm. thick.

An oesophagus (25) is present which is very short and wide, measuring 0·06 mm. in length and 0·2 mm. in width. It is really a part of the intestine inasmuch as it possesses its characteristic epithelium. The prepharynx, on the other hand, has the structure which usually characterizes the oesophagus of trematodes, as it possesses no epithelium and its lumen is bounded by a cuticula. It functions, in fact, as an oesophagus which has the pharynx at its hinder end instead of at its forward end.

The two intestinal trunks (20) pass at once transversely to the lateral areas of the body and then to the hinder end of it and are very wide, measuring 0·13 mm. in diameter. Their epithelium consists of cells which vary much in height and shape in different individuals. In one of the four worms sectioned they were simple cubical or somewhat elongated cells throughout the greater part of the intestine which did not possess terminal filaments. In the other worms examined the shape of the epithelial cells of the intestine had apparently been influenced by the food contents of the gut, and in a very interesting way. In the worm of which Figure 3 represents a cross section and Figure 4 a portion of the intestinal epithelium, the cells of this epithelium are, throughout a large part of the gut, considerably elongated, and with large nuclei, and from their free surfaces a fringe of long filiform protoplasmic processes extends into the lumen of the intestine. These processes are considerably longer than the cells themselves and four or five of them appear in a section extending from each cell (Fig. 4).

They are all of approximately the same length and are strikingly regular in form and outline. They have thus the appearance of large cilia, and might easily be taken for such.

In other portions of the intestine of this worm, especially toward the hinder end of the body, and throughout the entire gut of the other two worms examined, the intestinal epithelial cells lack the regular form of those just described, although they also possess similar long protoplasmic filaments. Their free surfaces show a tendency to throw large blunt extensions into the lumen of the intestine, which have the appearance of the pseudopodia of rhizopods and give these surfaces a most irregular contour. From these extensions as well as from the free surface of the cells generally the cilia-like structures project still further into the lumen of the intestine. They are however relatively much shorter than the corresponding structures shown in Figure 4, being not more than a third or half the length of the cells from which they spring.

The structure of the intestinal epithelial cells here described has been observed by other authors in a variety of trematodes. It was first described by Sommer (1880) in *Fasciola hepatica*. The explanations given by him of the cause of this formation is that the free ends of these cells become amoeboid in order to more quickly and easily digest the blood which has been ingested and forms the food of the parasite. A similar explanation may also serve for the same structures in *Stephanochasmus*, as the capacious intestinal trunks are usually filled with blood. I could not, however, find a correlation, as Sommer does in the intestine of *Fasciola*, between the amount of blood in the intestine and the actual form and conditions of its epithelial cells. Sommer finds that where the intestine is empty its epithelial cells are relatively low and simple in contour; and only in those parts of the intestine which are well filled with blood are the epithelial cells high and irregular in contour. In *Stephanochasmus casus* the intestine as observed always contained blood whatever the condition of the epithelium.

The musculature of the long prepharynx is a powerful one, consisting of regular circular and longitudinal fibres. On the intestinal trunks, on the other hand, the musculature is apparently absent, or at least is exceedingly delicate: it could not be demonstrated with certainty.

The excretory pore (Fig. 1, 15) is at the hinder end of the broad papilla which forms the posterior end of the body. The excretory vesicle (16) consists of a long median trunk and two long paired trunks which pass forward to the region of the oral sucker. The median trunk is a wide canal which extends forward to the space between the ovary and the anterior testis, or in much contracted specimens to that between the ovary and the dorsal body-wall. In the region of the testes it lies, as a flattened tube about 0·1 mm. wide, between these bodies and the dorsal body-wall. The two paired excretory canals are narrow tubes about 0·012 mm. wide which pass forward, one to the right and the other to the left of the ovary along the ventral surface of the intestinal trunks to the extreme forward end of the body. In front of the acetabulum they are much convoluted.

The genital pore (Fig. 1, 18) is median in position, being situated in the narrow space between the acetabulum and the transverse intestinal trunks, and opens into a long cylindrical genital sinus (Fig. 2). This structure, in a worm in which the cirrus is not extended (Fig. 2) and the body is much contracted, measures about 0·13 mm. in length: in a worm, however, the body of which is not contracted the genital sinus may be several times this length. It extends posteriorly either dorsal to the acetabulum or around one side of it.

The wall of the genital sinus (Fig. 5) is made up of a cuticula bounded by muscle fibres. The cuticula is continuous with that of the outer surface of the body, but is very different in structure. Instead of forming a smooth surface with large spines it is thickly set with short, perpendicular bristle-like projections (10) which arise near the outer surface of the cuticula and extend through it into the lumen of the sinus. These bristles may be compared with the spines of the outer cuticula. The muscle fibres consist of delicate circular fibres (4) surrounding the cuticula and powerful longitudinal fibres (22) which show a more or less rectangular cross section.

Joining the posterior end of the genital sinus are the cirrus sac (Figs. 1 and 2, 6) and the metraterm (24) which are extremely long, more or less cylindrical structures of about the same length, extending posteriorly to a point from a half to two-thirds the distance between the acetabulum and the ovary. Their actual position is dependent upon the condition of contraction of the body and whether the cirrus is extended or not. In Fig. 1, in which the cirrus (5) is extended and the body but little contracted, the cirrus sac is straight and not coiled and, not including the extended cirrus, about 1 mm. long, reaching back of the acetabulum to a point about half-way between it and the ovary, while the metraterm (24) is but slightly coiled and extends a short distance back of the cirrus sac. In Fig. 2, on the other hand, in which the cirrus is not extended and the body is much contracted, the cirrus sac (6) and the metraterm (24) are seen to be of equal length and to extend more than two-thirds of the distance between the acetabulum and the ovary and to be thrown into a series of irregular coils.

The outer wall of the cirrus sac (Figs. 6 and 7, 46) is a musculature, the fibres of which form a sort of felt and do not fall into circular and longitudinal layers although they have a general circular direction. Within this wall is the characteristic vesicular parenchyma in which are embedded numerous parenchyma cells (30).

The hinder fifth of the cirrus sac has a somewhat greater diameter than the forward portion and contains the vesicula seminalis (Figs. 1 and 2, 45). The remaining four-fifths forms a long slender tube which tapers slightly toward the forward end where it joins the genital sinus. Immediately anterior to the vesicula seminalis in this portion is the prostate region (35) which is short and contains the rather sparsely distributed prostate cells. The remainder of the lumen of the cirrus sac, constituting the anterior half or two-thirds, may be called the cirrus (Fig. 2, 5), of which only the anterior portion, however, can be extruded to form a functional penis (Fig. 1, 5).

The structure of the cirrus is similar to that of the genital sinus. Its lumen is bounded by a cuticula (Fig. 6, 8) which, like that of the genital sinus, is thickly set with perpendicular bristles. These extend through the entire thickness of the cuticula and into the lumen of the cirrus, giving it a very characteristic roughened surface.

It is only near its anterior end, however, that the cuticula has the character shown in Figure 6. A short distance back of the anterior end the perpendicular cuticular bristles become somewhat more delicate and embedded among them appear sparsely scattered spines of large size and peculiar construction. These spines are scattered at regular intervals and are very conspicuous objects (Fig. 7, 11). Each one consists of a bulbous base (Fig. 8, 3) which is embedded in the cuticula, lying near its outer surface, and a high cylindrical rim (13) which extends from the bulbous base to the inner surface of the cuticula. The total length of the bulbous base and the rim is thus equal to about the thickness of the cuticula of the cirrus. Extending now from the bulbous base through its cylindrical extension is a long slender spine which reaches beyond the general surface of the cuticula far into the lumen of the cirrus (Fig. 7, 11).

The structure of these peculiar spines is even more complicated than this description indicates. The bulbous base, which is spherical in shape, is made up of three regions: a thick basal disc (Fig. 8, 2), which lies near the outer surface of the cuticula, a thick-walled ring at the opposite side (36), through which the spine projects, and a middle portion which contains the broad inner end of the spine and appears lighter in colour than the other two portions. The spine is composed of a lighter coloured inner substance, and a darker periphery which is very thin and appears beaded (Fig. 8, 11).

These specialized spines are found throughout the entire extent of the cirrus (with the exception of the extreme anterior portion) and the prostate region. A short distance anterior to the vesicula seminalis they suddenly come to an end and the cuticula contains the cuticular bristles alone.

The musculature of the cirrus is not the same in all parts of it and enables us to divide the cirrus into two portions, the anterior, muscular, extrusile portion, which functions as the penis, and the posterior portion in which the muscles are weak. The musculature of the anterior portion is a continuation of that of the genital sinus and consists of rather delicate circular fibres (Fig. 6, 4) and a layer of powerful longitudinal fibres (22), which have a more or less rectangular cross section. The function of these strong longitudinal fibres in both cirrus and genital sinus is undoubtedly to thrust the cirrus out of the genital pore. They are the strongest towards the anterior end of the cirrus where they are a direct continuation of the longitudinal muscles of the genital sinus. Towards its posterior end they diminish in size and a short distance back of the acetabulum have the appearance shown in Fig. 7, 22. Still farther posteriorly both longitudinal and circular muscles become still less prominent and finally fade away altogether, or at least become difficult to demonstrate.

The function of the cuticular bristles and the cuticular spines of the cirrus is not easy to determine. In the extended cirrus they extend into the lumen with a general backward direction and would thus tend to check the flow of sperm towards the outside. Their function may be to prevent the too rapid emission of sperm.

The vesicula seminalis occupies the hinder portion of the cirrus sac (Figs. 1 and 2, 45). Its walls consist of a cuticula and muscle fibres. The cuticula is mostly plain and smooth and without the bristles or spines which characterize the cirrus. That of the anterior portion of the vesicula, however, shows transitional stages between the condition found in the cirrus and that of the vesicula.

The metraterm (24) has a structure which is essentially similar to that of the cirrus and the genital sinus. Its lumen is bounded by a cuticula (Figs. 6 and 7, 8) which is a continuation of that of the genital sinus and similar to it in structure, containing the same cuticular bristles. These bristles appear more delicate, however, than those in the genital sinus or in the cirrus. Embedded in the cuticula are also large, specialized spines similar to those in the cirrus (12). They differ from those in the cirrus, however, in some details of their structure. The base is not bulbous as in the cirrus, but is more or less flattened (Fig. 9, 2) and the cylindrical rim (13) reaching to the inner surface of the cuticula is longer. The spine (12) which projects from the base through the rim is usually somewhat shorter than in the cirrus and does not show the beaded periphery which characterizes it. These spines are present in every part of the metraterm and occur with about the same frequency as in the cirrus. They are not quite so conspicuous, however, as they do not appear to have such thick walls. At any rate they do not take stains so vividly as do the spines in the cirrus.

The character of the cuticula of the metraterm does not differ throughout its whole extent. The musculature is very delicate and consists of fibres which could not be separated into distinct layers.

The testes (Figs. 1 and 2, 40) are a pair of oval organs about 0·3 mm. long and half as thick which are situated one behind the other in the hinder half of the body. The posterior testis is usually somewhat longer than the anterior. When the body is much contracted the two testes are pressed closely together (Fig. 2); when it is much extended, however, they may be separated by a distance equal to about a quarter of their length. The vasa deferentia (Figs. 1 and 3, 44) pass forward to the cirrus sac.

The ovary (Figs. 1, 2 and 3, 28) is a spherical body 0·23 mm. in diameter which is situated directly in front of the anterior testis, often apparently somewhat at the left of the medial line. In a much contracted worm it may be closely pressed against the testis (Fig. 2, 28) and its shape changed to an oval. In worms whose body is fully extended it may be separated by 0·2 mm. from the testis.

The oviduct (Fig. 10, 29) emerges from the antero-dorsal surface of the ovary slightly to the left of the medial line and passes dorsoventrally a short distance to the median area of the worm where it is joined by the median yolk duct (23) and the Laurer's canal (21). It then passes forwards and immediately expands to form the uterus. This structure is short and thick, lying between the ovary and the hinder end of the metraterm and the cirrus sac and bounded laterally by the intestinal trunks. It is made up of two very distinct portions, the posterior or egg-forming portion (Figs. 1, 2 and 10, 42), which consists of two thick transverse folds and lies directly in front of the ovary, and the anterior or egg-storing portion (43) consisting of three or four folds which contain the eggs. The posterior or egg-forming portion represents the ootype of most distomes and is filled with sperm; it also contains a considerable number of the large eggs embedded in the sperm. This structure has been called the receptaculum seminis by Linton (1910). It is true that it contains sperm, but it is nevertheless not homologous to the receptaculum of other distomes inasmuch as it is a part of the uterus and contains also eggs. A receptaculum seminis in the ordinary sense is not present in any of the worms of this genus. An ootype is thus also absent in the form met with in other distomes. The condition of these organs in this worm may be considered a primitive one in that a specialized ootype has not developed from the posterior portion of the uterus. The eggs are of large size, measuring 0·06 mm. by 0·045 mm., and are few in number.

The yolk glands (Fig. 1, 47) are very voluminous, extending from the hinder margin of the acetabulum to the hinder end of the body, reaching thus farther forwards than in any member of the genus heretofore described. They completely occupy the lateral areas of the body, lying both dorsal and ventral to the wide intestinal trunks (Fig. 3, 47) and are bounded medially by the genital organs which occupy the medial areas of the body. The yolk glands consist of large follicles which are arranged in transverse rows extending from the periphery towards the centre of the body. The main transverse yolk ducts (Fig. 10, 41) meet dorsal to the ovary (Fig. 2) and not between the ovary and the anterior testis as in all other members of the genus, and form a large yolk reservoir (Fig. 10, 48) from which a long median yolk duct (23) passes antero-ventrally and unites with the Laurer's canal and the oviduct to form the uterus.

The Laurer's canal (21) is rather long and passes from the common meeting point with the oviduct, the median yolk duct and the uterus in a dorso-median direction to the opening in the dorsal body wall (Fig. 3, 38). In the section shown in this figure it is seen to be filled with sperm which protrudes from the opening. The cells constituting the shell gland (37) are grouped together about the Laurer's canal, the median yolk duct, the yolk reservoir and the oviduct between the ovary and the dorsal body wall.

It will be noticed that the complex of organs just described is not situated between the anterior testis and the ovary as is the case of the other species of this genus (Looss, 1901), but lie between the ovary and the dorsal body wall, and in case of greatly contracted individuals more or less in front of the ovary (Fig. 2). This is also true of much extended specimens, in which the ovary and the anterior testis are separated by a considerable distance: in these worms also these organs lie dorsal to the ovary.

Looss (1901) has shown that the species of the genus *Stephanochasmus* fall naturally into several groups which he thinks form sub-genera and may possibly be equivalent to genera. One of these groups is represented by *Stephanochasmus cesticillus* (Molin) and is distinguished by the greater width of the body behind than in front of the acetabulum, the extremely long cirrus sac and the ventral interruption of the oral spines. In another group, which is represented by *S. minutus* Looss, the hinder part of the body is also broad, the cirrus sac is relatively short and the oral spines are not interrupted ventrally. In the third group, which is represented by *S. pristis*, the body is not widened posteriorly, the cirrus sac is relatively short, the oral spines are not interrupted ventrally and the genital glands are separated from one another by wide spaces.

S. casus approaches nearest the second of these groups, being more closely allied to *S. minutus* than to any other species: It differs from it in being much larger, in having a relatively very long cirrus sac and in having yolk glands which extend forwards to the acetabulum.

Linton (1910) has described a worm under the name of *Lechradena edentula* which I believe to be identical with *S. casus*. Its structure is the same in every detail except that it is without spines. Linton found but a single specimen of the species which had probably lost its spines as a result of a slight superficial maceration, a thing which might very easily happen.

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Explanation of the Figures.

All the drawings except Figs. 8, 9 and 10 were made with the aid of the camera lucida.

1. Acetabulum. 2. Basal disc of cuticular spines. 3. Bulbous base of cuticular spines. 4. Circular muscles. 5. Cirrus. 6. Cirrus sac. 7. Cuticula. 8. Cuticula of cirrus. 9. Cuticula of metraterm. 10. Cuticular bristles. 11. Cuticular spines of cirrus. 12. Cuticular spines of metraterm. 13. Cylindrical rim of cuticular spines. 14. Eggs. 15. Excretory pore. 16. Excretory vesicle. 17. Fold of prepharynx. 18. Genital pore. 19. Genital sinus. 20. Intestine. 21. Laurer's canal. 22. Longitudinal muscles. 23. Median yolk duct. 24. Metraterm. 25. Oesophagus. 26. Oral spines. 27. Oral sucker. 28. Ovary. 29. Oviduct. 30. Parenchyma cells. 31. Pharynx. 32. Pigment granules. 33. Prepharynx. 34. Prostate cells. 35. Prostate portion of cirrus sac. 36. Ring disc of cuticular spines. 37. Shell glands. 38. Sperm. 39 Subcuticular cells. 40. Testis. 41. Transverse yolk duct. 42. Uterus (egg-forming portion). 43. Uterus (egg storing portion). 44. Vas deferens. 45. Vesicula seminalis. 46. Wall of cirrus sac. 47. Yolk glands. 48. Yolk reservoir.

EXPLANATION OF PLATE XIII.

Fig. 1. *Stephanochasmus casus*; dorsal aspect with extended cirrus, × 20.
Fig. 2. The genital tract; from a contracted specimen. × 40.
Fig. 3. Cross section of a worm through the Laurer's canal, × 100.
Fig. 4. The intestinal epithelium showing a regular arrangement of protoplasmic projections, × 500.
Fig. 5. Cross section of the genital sinus, × 300.
Fig. 6. Cross section of metraterm (24) and cirrus (5) near their proximal end, × 300.
Fig. 7. Cross section of metraterm (24) and cirrus (5) towards their distal end, that of the cirrus being somewhat diagonal, × 300.
Fig. 8. A single spine from the cirrus.
Fig. 9. A single spine from the metraterm.
Fig. 10. Diagram of the genital tract.

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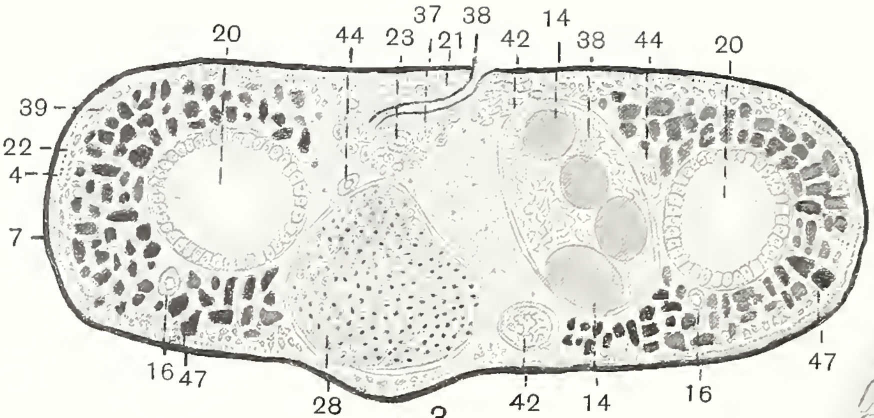

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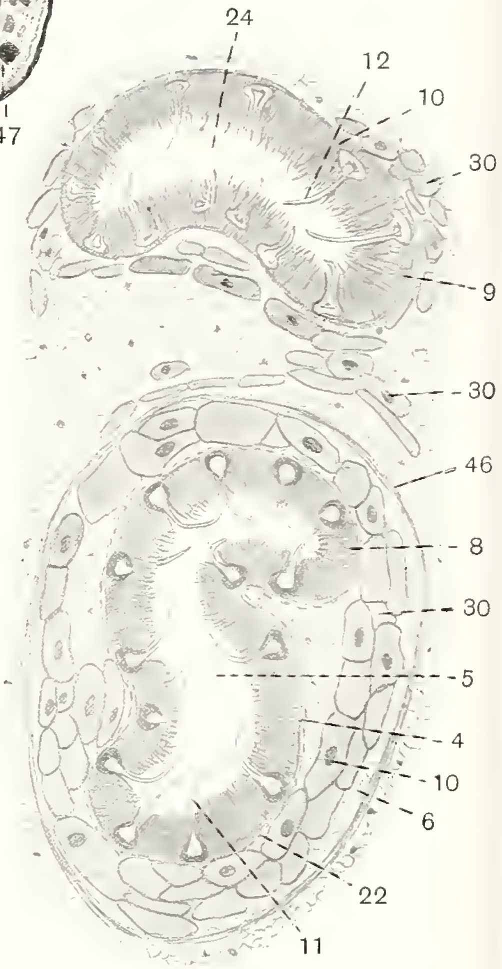

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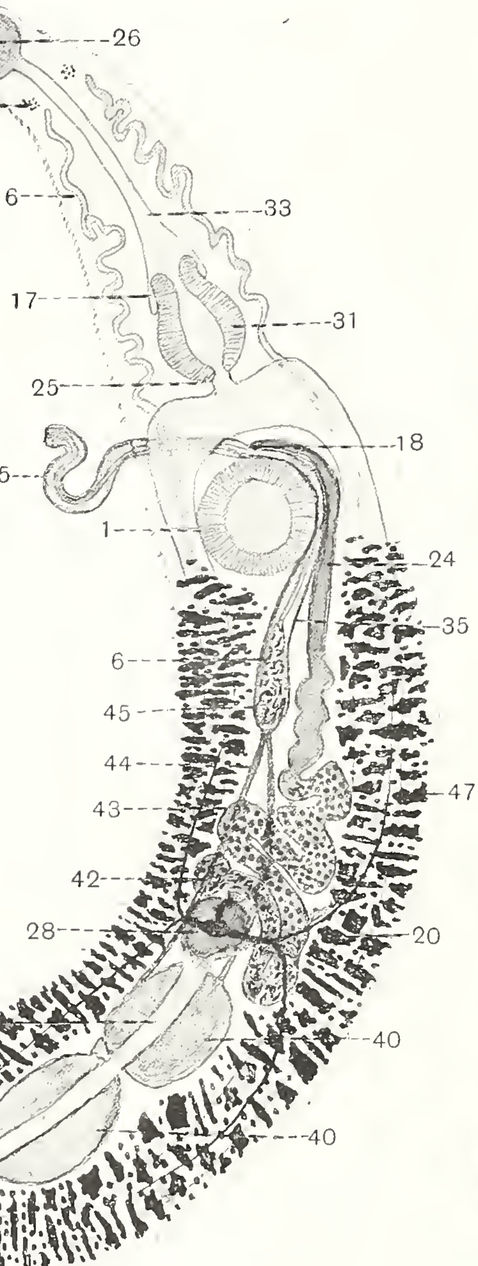

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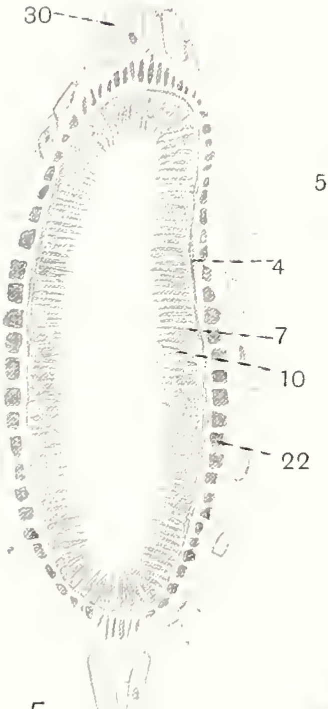

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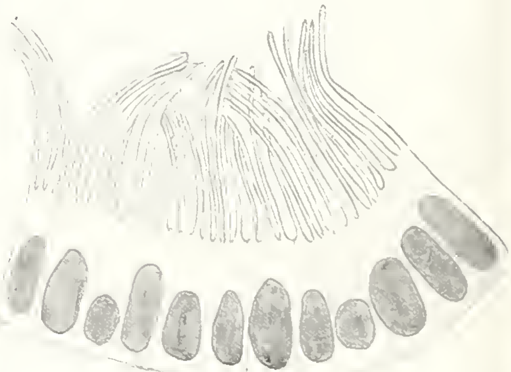

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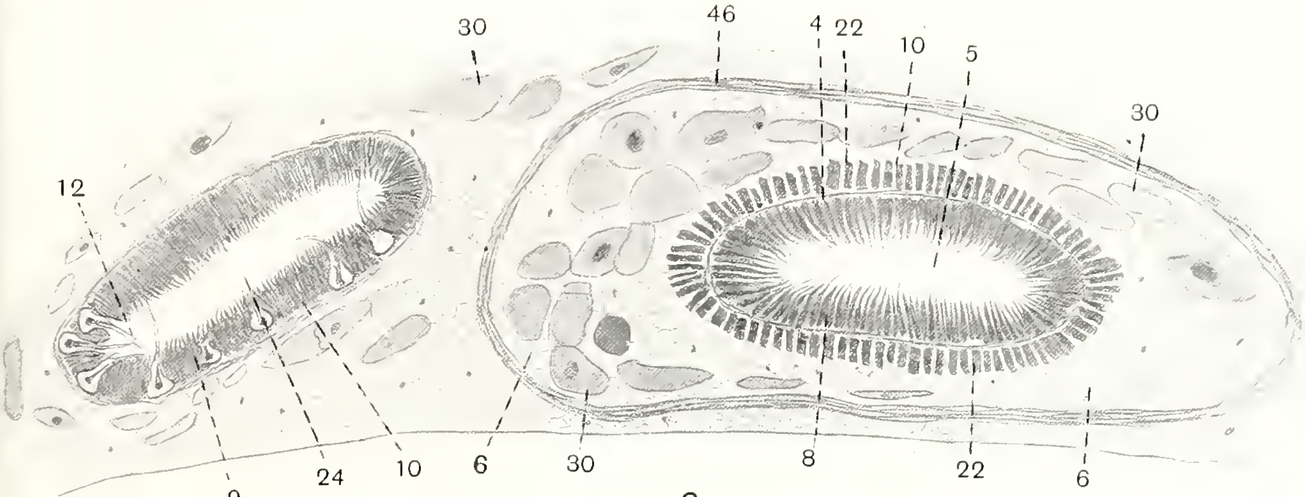
PLATE XIII



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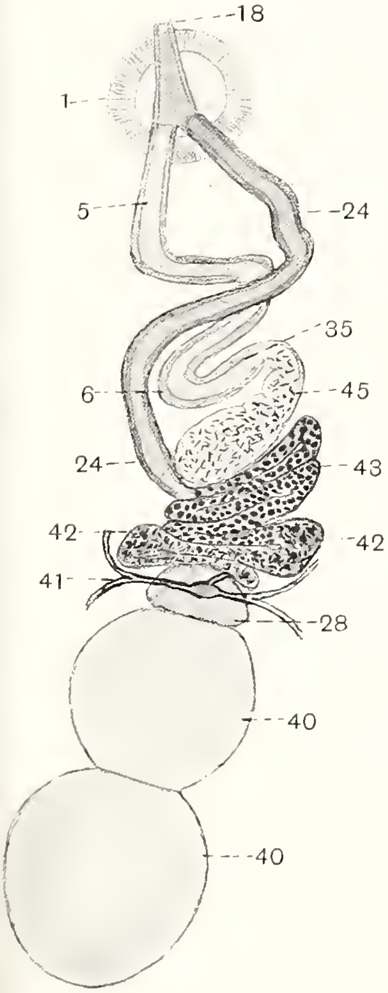

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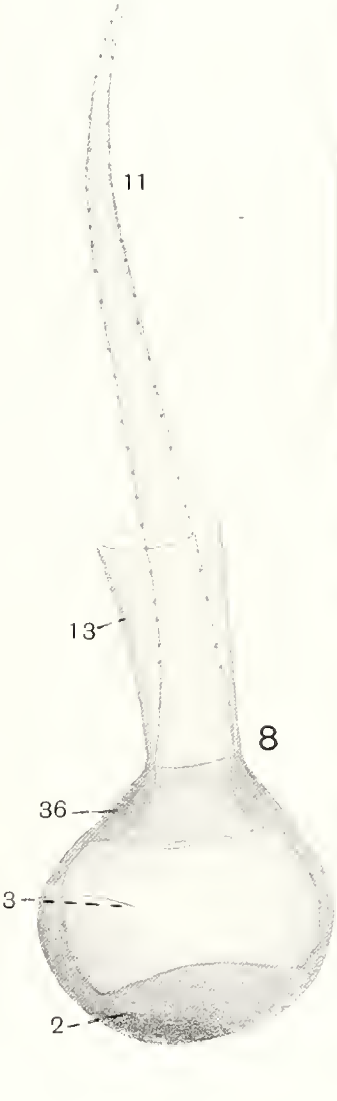

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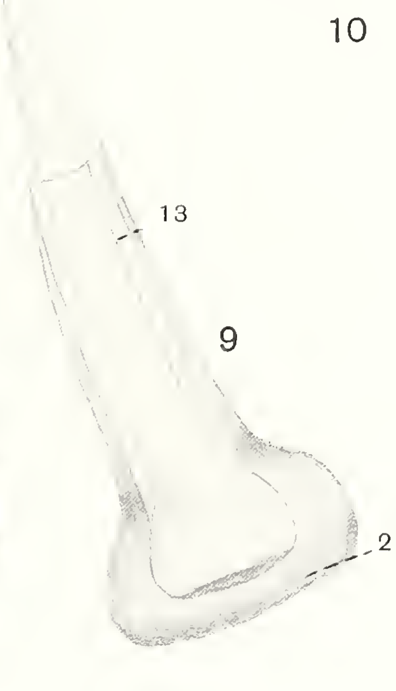

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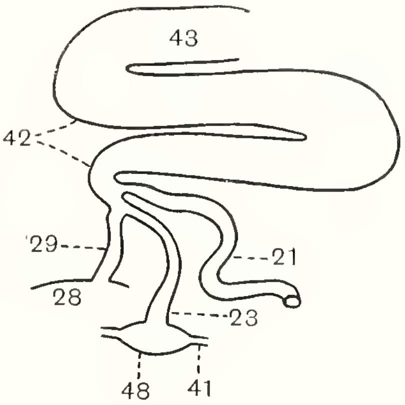

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BRITISH MUSEUM
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NATURAL HISTORY

A NOTE ON SOME HELMINTHIC DISEASES WITH SPECIAL REFERENCE TO THE HOUSEFLY AS A NATURAL CARRIER OF THE OVA.

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The incidence of Helminthiasis at Mombasa is herein briefly dealt with chiefly in tabular form. The tables give the result of the first 100 examinations conducted on natives of indigenous races *complaining of intestinal troubles*, admitted into or attending hospital.

Evidences of Helminthiasis were present in 83 per cent., absent in 17 per cent. Of the positive cases the percentages of the different ova of parasitic worms found were as follows:

Ankylostoma duodenale	46 %
Ascaris lumbricoides	44
Trichocephalus dispar	43
Taenia saginata	29
Schistosomum mansoni	5
Oxyuris vermicularis	2
Strongyloides stercoralis	3

Multiple infections are very frequent:

Single	34·92 %
Double	25·73
Triple	20·48
Quadruple	10·84

The chief single infections are *Ascaris lumbricoides* and Tape Worm. The more common double infections are:

Ascaris lumbricoides and *T. dispar*
Ankylostoma duodenale and *T. dispar.*

The more frequent triple infection is:

A. duodenale, *A. lumbricoides* and *T. dispar.*

Examination of Flies.

Shortly after war was declared a large number of porters came to Mombasa in connection with the Expeditionary Forces. Several cases from amongst these were admitted to the Native Hospital. One ward (No. 3) was set aside for them. Innumerable flies were attracted to this ward. Later, as more room was required for Indians in the two remaining wards, African cases, including fractures, were also put into ward No. 3. They, after varying intervals, also contracted bowel troubles, which were found to be due to intestinal parasites. The flies frequenting these wards lay under suspicion and an investigation was undertaken.

On 6. XI. 1914 an initial experiment was conducted with 50 flies taken about mid-day from ward No. 3. They were killed and placed in a $\frac{1}{2}$ oz. bottle with ether. After being shaken, some water was added and the flies were subjected to a thorough washing. The wash-water, on being centrifuged, yielded a very slight deposit which gave negative results on examination. All the flies were now well mashed up in ether, water was added, and the whole thoroughly mixed. The larger fly fragments which remained were carried up to the top of the fluid by the ether. The fluid below the level of the fly fragments was pipetted off and centrifuged. Washings with fresh water were repeated until enough fluid was obtained to fill the centrifuge tube. The tube was then centrifuged for two minutes. The deposit thus obtained was a deep blackish brown colour and was composed of finer débris from the flies. The deposit was drawn up in a pipette, the centrifuge being used after each pipetting, and 50 preparations were made of which 13 contained 29 ova.

The ova seen were those of	*T. dispar*	6
	T. saginata	15
	A. duodenale ..	4
	A. lumbricoides ..	4

As obviously one or two flies may have contained all of these ova it was decided to examine flies individually.

The tables give the results obtained from preparations made of the abdominal contents of each fly of a series of three hundred.

Native Hospital Ward No. 3 (27. XI. 1914).

Of 100 flies examined 10 harboured ova as follows:

Fly No.	Tri. d.	Tae. s.	Ank. d.
4	1	—	—
5	1	—	—
12	—	11	—
29	—	—	5
40	1	1	—
50	2	—	—
64	1	—	—
70	2	—	—
71	—	1	—
89	—	1	—

Attention was next directed to the Police Lines where some of the Askari were at the time known to be suffering from worms, chiefly *Tr. dispar*, *Taen. saginata*, a few with *Ank. duodenale* and two with *Sch. mansoni.*

Police Lines (21–28. XII. 1914).

Of 100 flies, caught at mid-day in batches as required, 11 harboured ova as follows:

Fly No.	Tri. d.	Tae. s.	Ank. d.	Sch. m.
7	—	3	—	—
13	—	1	—	—
14	—	—	3	—
27	18	—	—	—
29	1	—	—	—
44	—	1	—	—
64	1	—	1	—
65	—	—	—	1
73	1	—	—	—
75	1	—	—	—
84	—	3	—	—

Native Hospital (26. XII. 1914–12. I. 1915).

Of 50 flies, caught at mid-day as required, 6 harboured ova as follows:

Fly No.	Tri. d.	Ank. d.	Asc. l.
2	1	—	—
3	—	—	1
6	1	—	—
7	2	—	—
19	—	1	—
50	2	—	—

Meat Market (29–30. XII. 1914).

Of 25 flies, caught at mid-day, 2 harboured ova as follows:

Fly No.	Tri. d.	Ank. d.
8	2	—
19	—	2

Of 25 flies caught in a *house in the bazaar and at the hospital* about 6.30 a.m., none were found to harbour ova. The sexes of the flies were in the proportion of 21 ♂ to 4 ♀.

In the lots of flies collected in the other localities to which the previous protocols relate, the females were more numerous, all having been collected at mid-day; thus of 175 flies collected at the Native Hospital, in the Police Lines and Meat Market, of which the sexes were determined, 60 were ♂ and 115 ♀. Out of a total of 275 flies, separately examined, 29 (= 10 per cent.) were found to harbour ova; this excludes the last batch captured in the morning and which was so largely composed of male flies. The females contain worm ova much more frequently than do the males, the ratio in the positive results being 15 to 2. Whereas the females appeared as if they had recently fed, the males showed no such appearance. The discrepancy between the sexes is therefore doubtless due to differences in feeding habits.

Whereas the human faeces showed a high percentage of infection with the ova of *Ankylostoma duodenale* (46 per cent.) and *Ascaris lumbricoides* (44 per cent.), the ova of these species were only found in flies on five occasions and on one occasion respectively. On the other hand the ova of *Trichocephalus dispar* and *Taenia saginata* which were found in 43 per cent. and 29 per cent. of the samples of human faeces were encountered on sixteen and eight occasions respectively in flies. Finally, *Schistosomum mansoni* eggs which occurred in 5 per cent. of the human faeces examined, were encountered once only in a fly. The ova encountered in the flies were in the following order of frequency: *Trichocephalus dispar* (16), *Taenia saginata* (8), *Ankylostoma duodenale* (5), *Ascaris lumbricoides* (1), and *Schistosomum mansoni* (1). It should be noted, however, that in the first series of flies from the Native Hospital, the examination of the insects was carried out over a period of eight weeks during which the ova of *Ankylostoma* may have suffered through putrefaction changes occurring in the imperfectly preserved insects. No *Ankylostoma* ova were found in these flies after the fifth day.

The small number of *Ascaris lumbricoides* eggs found in the flies is doubtless due to their large size (short diameter 45μ) preventing their being swallowed by the flies, this being in agreement with the observations of Graham-Smith, who fed flies with food containing particles of different sizes. The ova of *Trichocephalus dispar*, judged by their appearance, withstand putrefaction in dead flies for nearly two months; the ova of *Taenia saginata* are less resistant in this respect.

The observations herein recorded indicate a method whereby prevalence of helminthiasis may be determined in a locality where it is either difficult or impossible to obtain faecal material for examination. There should be no difficulty in capturing the flies and preserving them in such a manner as to render their subsequent examination possible when leisure and opportunity permit.

OBSERVATIONS ON THE BLOOD IN EAST COAST FEVER OF CATTLE.

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The following records relate to a few observations made by me upon animals which Professor Nuttall experimented upon in 1911, at Cambridge.

1. *Enumeration of Red Blood Corpuscles.*

The red blood corpuscles were counted by means of Thoma-Zeiss's haematocytometer; the blood being collected from the animals as it ran freely from an ear vein. Usually 300 squares of the field were counted; on two or three occasions only were 200 squares counted. Our general impression is that the third drop from the pipette which is spread on the counting slide gives a higher reading than the two previous ones.

A series of counts were made with the blood of four cows. The first count was made before the animal was infected, the last a day or two before death; an intermediate count was made in the case of Cow IV.

		R.B.C. per c.mm.
Cow I	October 15	6,696,000
	November 4	5,528,000
Cow II	November 28	7,133,000
	December 15	6,960,000
Cow III	February 1	6,160,000
	February 14	5,927,000
Cow IV	February 24	4,340,000
	March 2	4,160,000
	„ 10	4,000,000

These observations confirm the statement by Theiler that there is a comparatively small decrease of the red blood corpuscles in East Coast Fever—there is very slight evidence of blood destruction.

These enumerations are in marked contrast to what is observed in *Piroplasmosis Canis*. Thus, in a dog, which was experimentally infected, the following counts were obtained:

		R.B.C. per c.mm.	
25. II. 1911.	Day 1	4,980,000	
	5	5,056,000	
	7	4,852,000	
	9	5,040,000	Piroplasma canis found in the blood
	11	4,240,000	
	13	3,130,000	
	15	2,118,000	

In this disease we see that the red blood corpuscles were being destroyed at the rate of about half-a-million daily.

The internal organs of cows which succumbed to East Coast Fever also showed little evidence that any blood destruction occurs. The spleen and liver were not enlarged or hyperaemic and the red bone marrow showed no signs of hyperplasia. The only macroscopic lesions observed were numerous petechial or minute haemorrhages along the course of the cardiac arteries in all cases. The differential blood counts which were carried out showed no evidence of hyperplasia of the blood-forming organs, i.e. there were no nucleated red corpuscles. It is well known that haemoglobinuria and icterus do not occur in East Coast Fever. Death may be due to toxaemia.

2. *Haemoglobin Estimations.*

A series of estimations of the amount of haemoglobin in the blood was obtained in the cases of three of the cows.

Barcroft's chemical method was used—the advantage claimed for this being that subjective errors are eliminated. The principle of the method consists in the reduction by means of Potassium Ferricyanide of a given quantity of laked blood fully oxidised. Oxygen is given off, and the pressure measured on an oil manometer. It is known what pressure is produced by a known weight of oxidised haemoglobin and so the haemoglobin of any sample of blood can be estimated.

The method is far too delicate and lengthy to take the place of colorimetric methods for clinical purposes, but for scientific purposes it gives very constant results. Two readings will seldom show a variation of more than 2½ per cent. on the manometer.

Our results are not given in terms of weight of haemoglobin, but of pressure of liberated oxygen in the manometer:

Cow II	November 26	26 mm.
	December 8	23 mm.
	,, 9	23 mm.
	,, 16	24 mm.
Cow III	February 4	15 mm.
	,, 15	16 mm.
Cow IV	February 24	16 mm.
	March 10	16·5 mm.

These figures show that the amount of haemoglobin in the blood undergoes no appreciable change during the course of the disease and they confirm the other evidence that no unusual blood destruction occurs.

3. *The Specific Gravity.*

Estimations were made of the specific gravity of the blood because it was thought that an actual decrease of the red corpuscles was perhaps being compensated for by an increased specific gravity.

The method used was the "jar method." A series of jars held mixtures of xylol and absolute alcohol in varying proportions so as to give fluids of a series of different specific gravity, these being calculated by using specific gravity beads. Into each of these jars a drop of the blood to be estimated was placed, and the fluid in which the blood neither rose nor sank gave the correct specific gravity of the blood.

		Sp. gr.
Cow II	December 1	1057·5
	,, 8	1055·5
	,, 9	1053·5
Cow III	February 5	1058
	,, 16	1057·5
Cow IV	February 25	1055·5
	March 7	1053

It will thus be seen that far from the specific gravity going up, it actually shows a slight decrease.

4. *The White Cells.*

The white cells were counted by means of Thoma-Zeiss's haemocytometer, using Toisson's fluid as a diluent. As a rule 375 squares were counted in three successive preparations, but sometimes only two preparations were made.

		White cells per c.mm.
Cow I	October 18	6640
	November 4	285
Cow II	December 1	4540
	,, 15	560
Cow III	February 1	3650
	,, 14	2940
	,, 16	2250
Cow IV	February 18	15616
	,, 24	11070
	March 2	6870
	,, 7	4320
	,, 10	1840

There is therefore a very marked leucopenia present in East Coast Fever, but it is difficult to explain its pathological significance.

This result is in marked contrast to the leucocytosis observed in a dog infected with Piroplasmosis.

		White cells per c.mm.
25. II. 1911.	Day 1	7950
	5	7900
	7	8666
	9	7900
	11	7100
	13	10000
	15	10250

Differential leucocyte counts.

We counted 500 white cells, with the following results:

Cow V	October 19		October 25		October 26	
Polymorphs	40·0		52		58	
Mononuclears	31·6	46	43	46	31·6	38·4
Lymphocytes	14·4		3		6·8	
Eosinophils	13·6		2		2·2	
Mast cells	0·6		0		1·4	

We cannot account for the abnormal number of *eosinophils* early in the course of the disease (the cow showed *Theileria* on October 13), but it may have some significance. The marked leucopenia, it will be seen, is caused by a greater relative decrease of the elements other than polymorphs, rather contrary to what usually occurs in protozoal diseases.

SUMMARY.

(1) There is very little, if any, abnormal destruction of erythrocytes in cases of infection with East Coast Fever. This is proved by blood counts, haemoglobin estimations, and the condition of the blood-forming and blood-destroying organs, all remaining practically normal. This is in marked contrast to what obtains in piroplasmosis.

(2) The hypothesis advanced by Nuttall fits all the facts. According to this hypothesis the invasion of the corpuscles occurs in the internal organs where the parasites develop, and the corpuscles only act as carriers of the parasites in the blood, thereby conveying them to the tick which serves as the vector.

(3) Since few, if any, of the corpuscles are destroyed they rapidly become charged with an increasing number of parasites which are being continuously produced in the internal organs as evidenced by Koch's blue bodies which form and break up in the lymphatic glands, spleen, liver, bone-marrow, etc. (Gonder, Nuttall).

(4) There is a marked leucopenia in East Coast Fever, the polymorphs decreasing less rapidly than the other elements. This is in contrast with the leucocytosis observable in piroplasmosis.

CONSIDERATIONS REGARDING AN OUTBREAK OF MALARIA AT MORIB, FEDERATED MALAY STATES.

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(*From the Malaria Bureau, Kuala Lumpor.*)

Morib being a seaside resort for the jaded European community of the State of Selangor, much consternation was caused when a succession of visitors there contracted fever. An investigation which I carried out at Morib leads me to publish this paper upon the epidemiology of the outbreak.

The endemicity of fever at Morib.

In the first place I ascertained that two of the cases among European visitors were first attacks. The infection may, however, have been acquired elsewhere and have previously remained latent. The other Europeans who were affected had all a previous history of fever and their illness may have been due to relapse brought about by cold or fatigue.

In the native population, however, the case rate pointed distinctly to the endemic origin of the fever. Moreover Mr Munro, late President of the Planters' Association of Malaya, who lives at Morib, informed me that fever has always been prevalent and that only the recent large influx of visitors has caused attention to be drawn to it.

The following notes will show the distribution of the cases, and the *spleen index*, among the local population in the vicinity of the Rest-house.

1. *Government Rest-house.* Of four Chinese servants two admitted that they had had fever while serving here; the head-boy who had been at the rest-house for four years had a greatly enlarged spleen.

2. *Malay servants living near the Rest-house.* Among these there were two married couples each with one child. The men both complained of suffering constantly from fever, and one of them had a greatly enlarged spleen. Only one of the women complained of fever, and she had an enlarged spleen. Both children, who had been born here, had high fever and enlarged spleens when I saw them—one of them was highly anaemic and cachectic; blood examination revealed parasites of malignant tertian malaria in both children.

3. *Chinese landed gentry behind the Rest-house.* The Towkay confessed to an occasional bout of fever. His son denied having had fever, appeared in excellent health and had no palpable enlargement of the spleen. A little daughter was also reported never to have suffered, and she had no splenic enlargement. On the other hand the coolie of the house was always ill, and he had great enlargement of the spleen and looked miserable. The blood of these people was not examined.

4. *Chinese shop-people of the village.* The village lies about one hundred yards from the rest-house as the crow flies, and any day a half-dozen of the inhabitants in the houses could be found prostrate with fever. There were only two children who had been born here; one of these had a palpable spleen. An examination of the blood was made in six adult cases, and crescents were found in two.

5. *Tamil estate coolies who lived in lines adjoining the village.* The manager of the coconut estate on which the Tamils worked, informed me that they were always contracting fever, and that they then left the village to recover at a spot two or three miles inland. I palpated the spleens of eight of the coolies, and found five with definite enlargement.

6. *European gentleman's compound* 300 *yards away from the village.* The *orang puteh*[1] himself suffered from a bad attack of fever when he first came here, while his servants are constantly down with it.

7. *Malay kampong*[2] *population.* Three houses were visited. In two of them the occurrence of a little occasional fever among the children was admitted, but in five cases the spleen was not palpable. In the third house, under one hundred yards away, two children were down

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[1] White man, a term only applied to English here.

[2] Small holding.

with fever and all of four children examined had enlarged spleens. Crescents were found in two of these cases.

Enough has therefore been said to show that the whole population here is subject to fever, and the fact that the children of the stationary population suffer, and present signs of chronic disease, proves almost conclusively that the fever is *endemic* in Morib.

Although some of the local residents attributed the fever to various causes it was clear to me that we were dealing with malaria. The physician who attended one of the patients informed me, moreover, that he had found malaria parasites in the blood, and that all the clinical symptoms were those of malaria.

The anopheline mosquitoes at Morib.

Having concluded that malaria was endemic at Morib, I proceeded to collect and study the mosquitoes which occurred in the locality, and captured five species: *ludlowi*, *rossi*, *umbrosus*, *sinensis*, and *tesselatus*.

We know that *ludlowi* (Christophers), *umbrosus* (Watson), and *sinensis* (Tsuzuki) have all been incriminated elsewhere as vectors of malaria, but it does not follow that they serve as vectors at Morib.

For instance I have found *ludlowi*, in great numbers, at Pasir Permatang over the river from Kuala Selangor, to mention but one place in the Malay States, and yet the natives never have fever there, and none of the children had enlarged spleens. Moreover Brooke reports that although *ludlowi* is very common at Cebu in the Philippines, yet there is no fever among the inhabitants. Similarly at Jeram, Selangor, a village very closely resembling Morib, except for the additional Malay fishing community at Jeram, I found large numbers of *umbrosus* in the fishermen's huts, although the spleen index of the Malay children (fifty examined) was practically *nil*. Again, in the case of *sinensis*, at Alor Pongsu in the state of Perak, the manager of an estate told me that at dusk anophelines came over like a flight of locusts, and I had the opportunity of seeing that, figuratively speaking, he was correct (I could easily have caught one hundred *sinensis* in five minutes if I had wished); nevertheless the manager's family, and the children of the two hundred Javanese coolies who lived a few yards away, never suffered from fever.

Enough has therefore been said to show that although three reputed malaria vectors were present at Morib, we should not be *à priori* justified in saying that any one of them conveyed malaria in that locality.

The relative prevalence of the different anopheline species is indicated by the numbers of each captured at Morib within a space of nine days:

(1)	*ludlowi*	..	236	of which	90	were ♀
(2)	*umbrosus*	..	39	,,	38	,, ♀
(3)	*rossi*	..	36	,,	15	,, ♀
(4)	*sinensis*	..	1	,,	1	,, ♀
(5)	*tesselatus*	..	1	,,	1	,, ♀

What we know of the relative infectivity of these species in other places, is as follows:

(1) *ludlowi:* Christophers, in the Andamans, found 2/53 of this species infected; it is thought that the parasites which de Vogel found in a *rossi*-like mosquito were really found in *ludlowi.* Horne in India has also reported finding *ludlowi* infected.

(2) *umbrosus:* Watson has found this species infected, but he does not state what proportion were infected; it is reported that it has also been found infected in Borneo. Stanton found that of eleven specimens which had been exposed to infection not one was parasitised. I had previously examined about six of these mosquitoes with negative results.

(3) *rossi:* Eysell contends that several observers have found this species infected, but it seems doubtful whether the species has not been confused with *ludlowi.* Stanton dissected 136 specimens but found none parasitised.

(4) *sinensis:* this species certainly becomes parasitised (Tsuzuki, Kinoshita). Stanton found zygotes in two out of ninety-eight specimens which had been exposed to infection.

(5) *tesselatus:* nothing is known regarding the behaviour of malaria parasites in this species.

To these data may be added the result of my dissections at Morib as follows:

	No. examined	No. found infected
ludlowi	80	0
umbrosus	38	0
rossi	13	0
sinensis	1	0
tesselatus	1	0

Conclusions on relative infectivity drawn from these figures would certainly be fallacious. It is very probable that *rossi*, if infective, is only infective to a much less degree than the others. Although about 2 per cent. of *sinensis* have been found to be infected in Malaya, the presence of this mosquito in great numbers in certain districts without causing malaria is in marked contrast to what we read of the amount of sickness caused by *umbrosus* and *ludlowi*: it is therefore probably less infective than these two species. We have only a little indirect evidence that *umbrosus* is probably less infective than *ludlowi*, viz.: at Jeram where there was no malaria, we caught large numbers of *umbrosus* in a few minutes, yet at Morib only thirty-eight were captured in nine days. The conditions, as said before, were almost identical. It is probable that at Morib very little of the fever was being caused by *umbrosus* and most of it by *ludlowi*.

At Morib it would seem that *rossi* and *sinensis* are both negligible factors in the situation; and this view is borne out by observations in other localities mentioned above, where, in spite of great numbers of these species, there was no fever. The conclusion we came to was that *ludlowi* was the greater cause of trouble, not only because of its probably greater infectivity, but also because of its greater numbers than *umbrosus*.

These conclusions by their necessary lack of precision show us how useful it would be if we had an accurate table of the relative infectivity of the different species, for we might then by merely counting the relative numbers of the prevalent species in any place find out exactly their relative culpability, and act accordingly.

With regard to preventive measures it would seem that greater success might be anticipated from a campaign against a mosquito, which was causing trouble more by reason of its large numbers than its high infectivity, than against a mosquito which was of high infectivity and low prevalence, for it is obvious that a larger *proportion* of the former type would be found and destroyed. This hypothesis might account for the great success which has attended Watson's antimosquito measures in the Federated Malay States in places like Port Swettenham, and for the comparative lack of results in the hill-country, for in a place like the former, *ludlowi*, the chief cause, as we think, of the fever, is a mosquito of relatively low infectivity, but of usually great prevalence. It breeds in enormous quantities, this being probably due to the larval characteristic, as in *rossi*, of disappearing on the slightest approach of danger. On the hill-land, on the other hand, *maculatus* and *albirostris* are never to be found in such great numbers, but they possess great infective powers. It follows that if malaria is easily allayed by antimosquito measures in any community, none of the local anophelines are highly infective.

At Morib therefore, the prospects would seem excellent of greatly reducing the disease by anti-*ludlowi* measures.

SUMMARY.

Consideration of the outbreak of fever at Morib in Selangor, Federated Malay States, impresses us with the great practical importance of obtaining an exact comparative infectivity table of the various anophelines, compiled on a comprehensive basis; it is only by accurate study of a disease and the factors responsible for it, that it can be successfully combated.

At Morib we can only rely on general considerations and conclude that the species *ludlowi* has been causing most of the trouble.

It would seem that the reason that hill-land malaria in Malaya, and perhaps India, is so difficult to get rid of is because it is conveyed by mosquitoes of high infectivity and low prevalence, whereas low-land malaria can be easily allayed because it is conveyed by mosquitoes of low infectivity and high prevalence. It is a corollary to this that if malaria in any community can be easily allayed, it is caused by mosquitoes which possess low infectivity.

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THE OCCURRENCE OF *PNEUMOCYSTIS CARINII* IN MICE IN ENGLAND.

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(With 8 Text-figures.)

INTRODUCTION.

A FERTILE source of error in protozoology is to be found in the overlooking of the occurrence of mixed infections in a host. Two organisms, each independent of the other, may happen to coexist in the intestine of an insect or the blood of a vertebrate, the result being that the investigator may confuse stages in the life-cycles of parasites which are not related to each other. This source of error has led to unwarranted generalisations which have impeded scientific progress for years. Two examples at once come to mind—the trouble wrought by Schaudinn in 1904 in confusing the life-cycles of the protozoa found in the little owl, and the impediment put in the way of progress by the omission of certain workers to recognise that *Crithidia grayi* was not a part of the life-cycle of a trypanosome. The existence of mixed infections was overlooked in each case.

PULMONARY CYSTS. HISTORICAL.

A third example of confusion of identity occurred in connection with *Trypanosoma* (*Schizotrypanum*) *cruzi*, wherein Chagas (1909, 1911) described two forms of schizogonic development of the parasite. One form, occurring in many tissues, is generally accepted, but around the other, which is said to occur in the lungs, controversy has arisen. Certain trypanosomes in the lungs of vertebrate hosts were said to become round and then eight-nucleate, giving rise to eight vermicular merozoites. These daughter forms were considered by Chagas to be merozoites of *T. cruzi.* Later, Carini (1910) found similar rounded encysted structures in the lungs of rats in São Paulo, Brazil, the hosts being infected with *T. lewisi.* Vianna (1911–12) found pneumocysts in the lungs of animals infected experimentally with *T. gambiense, T. equinum, T. congolense* and *T. equiperdum*, whence the cysts were considered to be stages in the life-cycles of those trypanosomes. However, M. and Mme Delanoë (1912), working at the Institut Pasteur, Paris, found similar structures in the lungs of rats immune to *T. lewisi.* They doubted whether the cysts were an integral part of the life-cycle of the trypanosome, and considered that they might be separate organisms for which the name *Pneumocystis carinii* was suggested. Their subsequent work in 1914 has confirmed the opinion that *P. carinii* is a separate entity, for it has been found in animals not infected with trypanosomes. Chagas (1913) revised his statements regarding the schizogony of *Trypanosoma cruzi*, and was supported by Aragão (1913). Carini (1914) has now accepted *Pneumocystis carinii* as an independent organism.

Pulmonary cysts have also been found in rabbits, dogs, cats, lambs and goats, and possibly in man. They seem to have been observed more particularly in Brazil and in France. Coles (1914) found pneumocysts in one rat in the south of England.

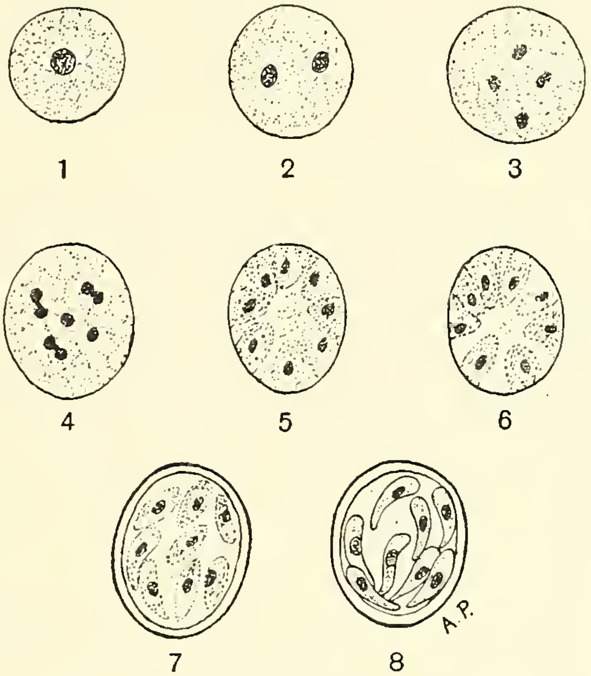
PNEUMOCYSTIS CARINII IN MICE.

So far as I am aware, *P. carinii* has not been recorded from mice, at any rate in England. During last year, I examined a wild mouse killed accidentally at Cambridge. The body was well nourished and in good condition. No parasites were found in the peripheral or heart blood. On very finely teasing a small portion of one of the lungs, and examining the preparations either fresh and unstained, or stained intra vitam with methylene blue, a number of small bodies corresponding to *P. carinii* were seen. Portions of organs other than the lungs yielded no parasites. Fourteen other mice since examined for pulmonary cysts have been negative.

The various stages of *Pneumocystis*, as seen in a mouse, may be briefly described:

The youngest cysts seen were spherical or oval bodies, 4μ to 5μ in diameter. They were uninucleate and their cytoplasm was finely granular or slightly alveolar. Chromatinic structures other than the nucleus were not seen (Fig. 1). The cysts were either free or were contained in endothelial cells. A cyst wall, of varying degrees of thickness in different specimens, was usually present.

Older cysts showed two (Fig. 2), four (Fig. 3) or eight (Fig. 5) nuclei. In some cases, the nucleus was in process of division into two, and a strand connected the two daughter nuclei. These nuclei were not always equal in size, and one of them at times simulated a blepharoplast. Binary fission, three times repeated, resulted in the production of an eight-nucleate organism (Fig. 4). Cytoplasmic cleavage into eight portions followed (Figs. 5, 6), and eight merozoites were gradually produced (Figs. 7, 8). Fully mature cysts measured 5μ to 6·5μ in diameter.



Figures 1—8.

Pneumocystis carinii, as seen in the lung of a wild mouse in England. × 3000

1. Uninucleate parasite. 2. Binucleate form. 3. Organism with four nuclei. 4. Parasite showing the progress of the division of the nucleus into eight. 5. Commencement of cytoplasmic segmentation. 6. 7. Merozoites differentiating. 8. Pneumocyst containing eight fully formed vermicular merozoites.

Each merozoite was a small vermicular body with a single nucleus. The length of the merozoite was 1·5μ to 2·5μ, and its breadth about 0·5μ. The free merozoites were slow in movement, and rapidly lost their vermicular appearance, becoming rounded. All the merozoites observed had the same kind of staining reactions and there was no morphological or biological character that could be interpreted in terms of sex.

The degree of infection of the mouse was slight.

The mode of transmission of the parasite has not yet been determined. It seems probable that *Pneumocystis carinii* passes from host to host by the contaminative or casual method. The presence of a cyst wall around an organism is usually a protective adaptation for ensuring survival outside the body of the host. The occurrence of such a cyst in *P. carinii* suggests that the parasite leaves the host in the encysted condition, probably by way of the mucus in the oral or nasal secretions.

The zoological position of *P. carinii* is not yet fully established. The experiences of a number of workers have shown that the organism is unconnected with any trypanosome. In my own case, the mouse harboured no trypanosomes in its blood, nor did I find *Leucocytogregarina musculi* to be present. Coccidia were absent from the gut.

Delanoë suggested that the organism is possibly a *Coccidium* of the lung of its host. At present there is lack of knowledge of differentiated sexual forms, and until further stages of the life-cycle are known, the definite systematic position of *Pneumocystis carinii* cannot be stated.

Before concluding, I should like to refer again to *Leucocytogregarina musculi* Porter 1908, parasitic in the leucocytes and internal organs of mice. At one time, I thought that *Pneumocystis carinii* might possibly be a part of the schizogonic phase of the former organism, though *Pneumocystis* appears to be somewhat small in size compared with the known schizonts and merozoites of *Leucocytogregarina musculi.* The recent suggestion of A. C. Stevenson (1915) that *L. musculi* and *Klossiella muris* are stages of one organism is so far not supported by facts and seems to me improbable.

CONCLUSIONS.

Pneumocystis carinii has been found in the lungs of a mouse in England. The cysts are spherical or oval and are 4μ to $6{\cdot}5\mu$ in diameter; eight merozoites are finally formed within them. The organism appears to be an independent parasite of the lungs of certain vertebrates, and to be unconnected with any trypanosome.

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ON THE OCCURRENCE OF HERPETOMONADS (?) IN GERBILS.

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I WAS much interested in the paper on Herpetomonads in mice in the June number of *Parasitology* (Fantham and Porter, pp. 128–132). In 1904 or 1905 when working at trypanosomiasis at Khartoum I came across a flagellate in the peripheral blood of a gerbil (*Gerbillus pygargus*) which was clearly not a trypanosome and the nature of which I was unable to identify.

The facts are as follows:

My laboratory assistant, Mr Friedrichs, was examining a cover slip preparation from one of the control animals and observed a very actively moving parasite amongst the red blood corpuscles. He called my attention to it and I examined the film with much interest, for it seemed clear that we were dealing with a new blood parasite. It was not easy to examine, for its movements were exceedingly rapid and jerky, but I could see that it was flagellated and I specially noticed that its posterior end was curved or flexed a little upon itself so that it resembled a hook.

After watching it for a little I was called away and my assistant by some mistake unfortunately removed the cover glass and cleaned it and the slide so that I was unable to study the film further or to obtain a stained preparation. There was, so far as I could tell, only the single parasite in the film and I am certain that it was not a trypanosome, although a trypanosome of the *T. lewisi* type has been found in the Sudan gerbil. The gerbil was still available and I examined a large number of blood films from it but I failed to find any other parasites in its blood. So far as I can remember I also examined blood obtained from it post-mortem without result.

I merely made a mental note of this finding, telling Dr Wenyon about it when he visited Khartoum, but though I subsequently examined the blood of hundreds of gerbils in connection with trypanosome and other work I never saw anything like this particular parasite again until Captain Archibald several years later one day came across a solitary example of what was evidently the same flagellate in the blood of another gerbil of the same species.

Its appearance and movements in the coverslip preparation having been duly noted, the cover glass was slipped off, the blood allowed to dry on it and the slide and the films carefully stained in the confident expectation that its morphology would now be fully revealed.

Strange to say the parasite could not be found despite prolonged and repeated search. The gerbil was sacrificed but its further examination yielded no results. Although I am not prepared to say this flagellate was an herpetomonad I am inclined to think it may have been after reading the descriptions given by Fantham, Porter, Dutton and Todd. It is interesting to note that the two former authors were unable to obtain stained preparations of the herpetomonads in the blood of their mice and that Dutton and Todd speak of their parasites sometimes assuming an "S"-shaped form. It may be that the hooked form of one extremity of the flagellate I first saw was due to a movement of this nature.

I believe that this parasite in the blood of gerbils was not due to any accidental contamination, but one must remember this possibility both as regards faecal and seminal contamination. It is curious that Captain Archibald's experience was nearly identical with mine. We decided to say nothing about it as we fully expected to encounter the parasite again, but this did not prove to be the case.

In the light of Fantham and Porter's communication, however, it now seems advisable to mention the occurrence of this peculiar and rare flagellate in the peripheral blood of gerbils in the Sudan, as further search may again reveal its presence and enable some other observer to come to a definite conclusion regarding it.

The flea most commonly found both on gerbils and jerboas in the Sudan is *Pulex cleopatrae*, and it was in this species of flea that in 1906 I found herpetomonas infection to be common, as described in the *Journal of Hygiene*, 1906, vol. VI, No. 5, and subsequently in the *Second Report of the Khartoum Laboratories.*

LERNAEOPODA SCYLLICOLA n. sp., A PARASITIC COPEPOD OF *SCYLLIUM CANICULA.*

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Part I.

(With 6 Text-figures.)

Habitat and Record. The animal under consideration, a parasitic member of the Copepoda, and belonging to the family Lernaeopodidae, occurs commonly on the males, and much less frequently on the females, of *Scyllium canicula.* The point of fixation is just outside the cloaca, between the pelvic fins, the parasite remaining attached permanently by the second maxillae to the tissues of the host, and occasionally even to the claspers, on their sides, preferably in the groove. I have several times found as many as six specimens on one host (Fig. 1), while three or four is a usual number.

Only the females are dealt with in this paper. Considering the hundreds of dogfish used every year by students for the purposes of dissection, and that this parasite appears on the majority of them, I was astonished that neither Scott (1912–13) in an account of British Copepods, nor Wilson (1915) in his excellent and voluminous monograph on the family Lernaeopodidae mentions any parasite whatever occurring on *Scyllium.* Bassett-Smith (1896), who worked at Plymouth, fails also to record any Copepod upon *Scyllium.* Richiardi (1880) was apparently the first to mention a species which he considered new belonging to this family and occurring upon *Scyllium stellare,* but as he gave neither description nor figures it cannot be certain that he was dealing with the same parasite as that which I am at present considering. Brian (1898) degraded *Lernaeopoda scyllii* Richiardi 1880 as synonymous with *L. galei* Krøyer 1837, from specimens found on *S. stellare* and *S. canicula,* but he did not assign any reasons for his decision. Krøyer's figures are too small and ambiguous to be enlightening, and in comparing my examples with *L. galei* I am following as regards the latter the figures of Scott[1]. Unfortunately all subsequent authors appear to have taken Brian's statement upon trust, and not to have investigated parasites from *Scyllium* independently. The animal here considered may or may not be *Lernaeopoda scyllii* Richiardi; if not it must be a new species, since Richiardi's species is purely nominal. My specimens differ from *L. galei*, as figured by Scott and described by Wilson, amongst other points in the character of the maxillipedes and in the shape of the mandibles. The characters of the other appendages, the two pairs of antennae, and the first maxillae, are practically constant in all the

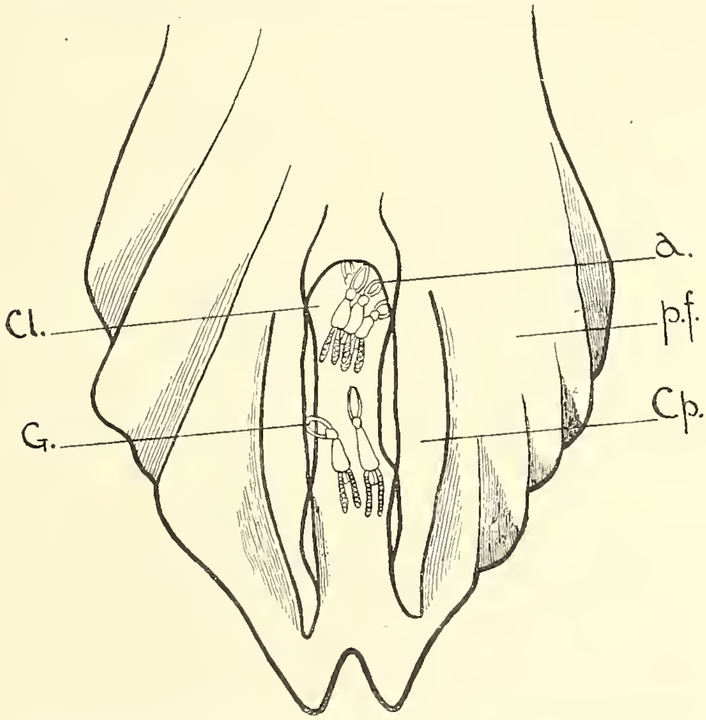

Fig. 1. *Scyllium canicula* ♂, the pelvic region showing six parasites, *Lernaeopoda scyllicola in situ*. *p.f.* pelvic fin; *Cl.* extra-cloacal region; *Cp.* claspers; *G.* groove in clasper to which one animal was on this occasion attached; *a.* the more usual place of attachment.

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[1] Since going to press I have had the opportunity of examining a specimen from the Norman collection at the British Museum (Nat. Hist.), identified as *Lernaeopoda galei* Krøyer, from Polperro in 1862. The specimen mounted on a slide is labelled "from the smooth hound" (but the spirit-preserved specimens under same date and place are labelled "from *Galeus vulgaris*"). The appendages and mouth parts of this mounted specimen agree, in the major part, with the figures of Scott, and differ, especially in the maxillipedes, from the species now under description.

many species of *Lernaeopoda*; failing access to Richiardi's types my specimens must be regarded as belonging to a new species for which I propose the name *Lernaeopoda scyllicola*.

Of other authors (beside Brian) who have found the alleged *L. galei* upon *Scyllium*, and, as far as I can discover, any Copepod parasite upon *Scyllium* (all spp.) we have only van Beneden (1851, upon *Scyllium canicula*).

The parasite was particularly abundant on *Scyllium canicula* taken at Plymouth in 1914–15.

Author	Host	Name of Parasite	Locality
Krøyer	*Squalus galeus* (Linn.)	*Lernaeopoda galei*	
	Squalus acanthias	*L. galei*	
van Beneden	*Mustelus vulgaris*	,,	
	Scyllium canicula	,,	
	Trygon pastinaca	,,	
Richiardi	*Scyllium stellare*	*L. scyllii*	
	Mustelus equestris	*L. galei*	
Brian	*S. stellare*	,,	Porteferraio
	S. canicula	,,	Porteferraio
Leigh-Sharpe	*S. canicula*	*L. scyllicola*	Plymouth Coasts of Devon and Cornwall

Body. The outline of the animal is best seen from Fig. 2. The total length of an average preserved specimen is about 21 mm. which is made up as follows: *2nd Maxillae* 7 mm.; *Trunk* 7 mm. (of which 2 mm. is occupied by the *Cephalothorax*); *Ovisacs* from 5 mm. (usually) to 7 mm.; the *Abdominal appendages* 3 mm., their length being coincident with the ovisacs[1].

The animals are greyish-white or yellowish-white in colour. The yellow bands mentioned by van Beneden appear to be the muscles, which are very beautiful representatives of the striped variety showing through the chitinous envelope.

The *Cephalothorax* is comparatively small, inclined to the trunk axis, oval in outline, strongly flattened dorsi-ventrally, and covered with a distinct dorsal carapace.

The *Trunk* is slender, and a narrow neck is shown where it joins the cephalothorax. The first one or two segments of the thorax alone are differentiated, the rest are indistinguishably fused with one another and with the abdomen. The trunk is broadest and thickest at the posterior end where it bears two abdominal appendages or processes, which are *ventral to the ovisacs* (generic character) and diverge from one another. Between these appendages is a minute genital process (Fig. 6). There are no anal laminae.

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[1] The dimensions of *L. galei*, according to Wilson, are: total length 10–15 mm.; *Cephalothorax* 1·5 mm.; *Trunk* 9 mm. (*posterior processes* 2 mm.); *ovisacs* 10 mm.

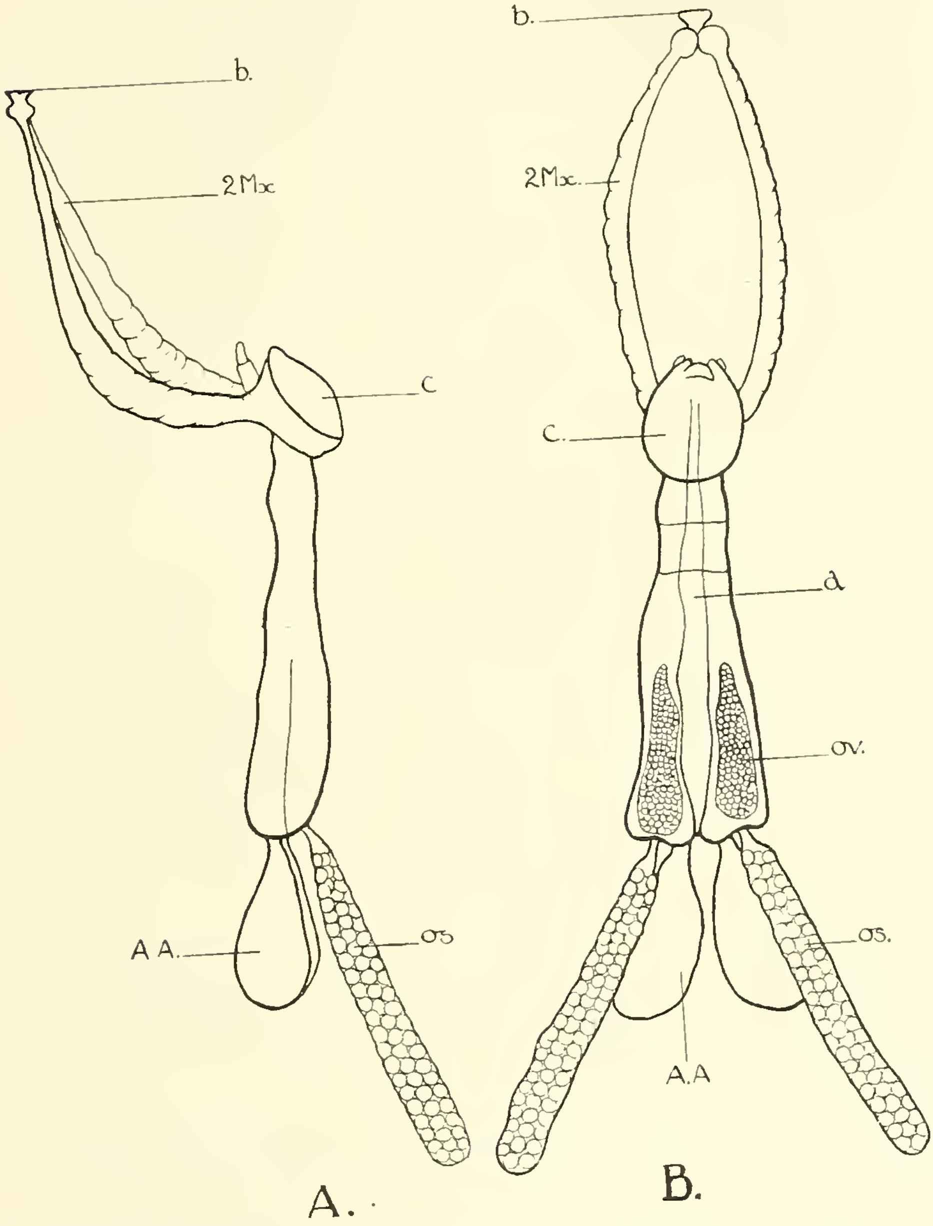

Fig. 2. *Lernaeopoda scyllicola*, the entire animal, A viewed from the left side, B in dorsal aspect. *b.* bulla; *2Mx.* second maxillae; *c.* cephalothorax; *a.* alimentary canal; *ov.* ovary; *os.* ovisacs; *A.A.* abdominal appendages.

The **Appendages**, all paired, are: 1st Antennae (Antennules), 2nd Antennae, Mandibles, 1st Maxillae, 2nd Maxillae, Maxillipedes.

The 1*st Antenna*, or *antennule* (Fig. 3 A), is four-jointed, and the basal joint is much enlarged, somewhat spherical and having a curious spiral turn upon itself. Of the other three joints the terminal is the largest, and the middle one slightly the smallest. This agrees with Scott's description of *L. galei* but not with Wilson's, the latter stating that the distal three joints diminish regularly in size. The terminal joint bears at its extremity five (sometimes six) mammillated spines, one of which, on the inner border, is markedly larger than the rest.

The 2*nd Antenna* (Fig. 3 B) consists of a basal joint bearing a large unjointed endopodite with a round or blunted end, and a small exopodite, whose diameter is half (not a quarter) of that of the endopodite, and which is distinctly two-jointed, the terminal joint bearing one prominent spine, and at least one accessory one (not several small spines).

The *Mandible* (Fig. 3 C) is slender and aciculate: the teeth are not rounded, and do not resemble Scott's figure of *L. galei.* They bear a similitude to Kurz's figure of *Achtheres selachiorum* which is said to be a synonym of *L. galei.* The teeth are saw-like, the serrations being on the inner side of the blade, and pointing posteriorly. The mandibles are inside the proboscis, although they originate on the outside of the ventral surface of the head (Fig. 5 *Mn.*) and only become enclosed when the edges of the upper and lower lips are fastened together. The base of the mandible is outside the proboscis, inserted in a fold of the skin, and only the blade or terminal portion enters the mouth tube through a triangular opening at the base of the two lips. The blade of the mandible reaches to the tip of the proboscis, or may even project a little way beyond it. It is widest at the centre, a constriction occurring where the blade originates from a triangular proximal basal plate, causing it to curve towards the mandible of the opposite side. The operation of the mandibles is described by Kurz (1877) and quoted by Wilson (1915).

The 1*st Maxilla* (Fig. 3 D) consists of an unsegmented endopodite, and a well-developed exopodite or palp which is jointed and tipped with three short curved spines (not two as in *L. galei*). The endopodite is tripartite at the distal end, one ramus being terminal and the other two on the inner margin. Each ramus ends in a soft mammillated spine. This appendage is the most constant one throughout the various species of the genus *Lernaeopoda.*

The 2*nd Maxillae* (Figs. 2 and 4 A) are *as long as* the trunk, slender, cylindrical, and swollen or enlarged at the distal ends[1]. They are the principal organs of attachment. When first they arise in the metanauplius stage they are clawed appendages similar to the maxillipedes. In the free-swimming or first Copepod stage, when the larva attaches itself to the host, the 2nd maxillae are fastened to the proximal end of the frontal filament. In the female this union of filament and maxillae becomes permanent throughout life, and the two fuse thoroughly until all that is left of the filament is the *bulla or button* which joins the tips of the maxillae and serves to anchor them firmly in the tissues of the host (Fig. 4 A). The parasite once attached becomes incapable of change of position, but the length of the "arms," as the two maxillae are often called, which are separate to their tips allows of a considerable

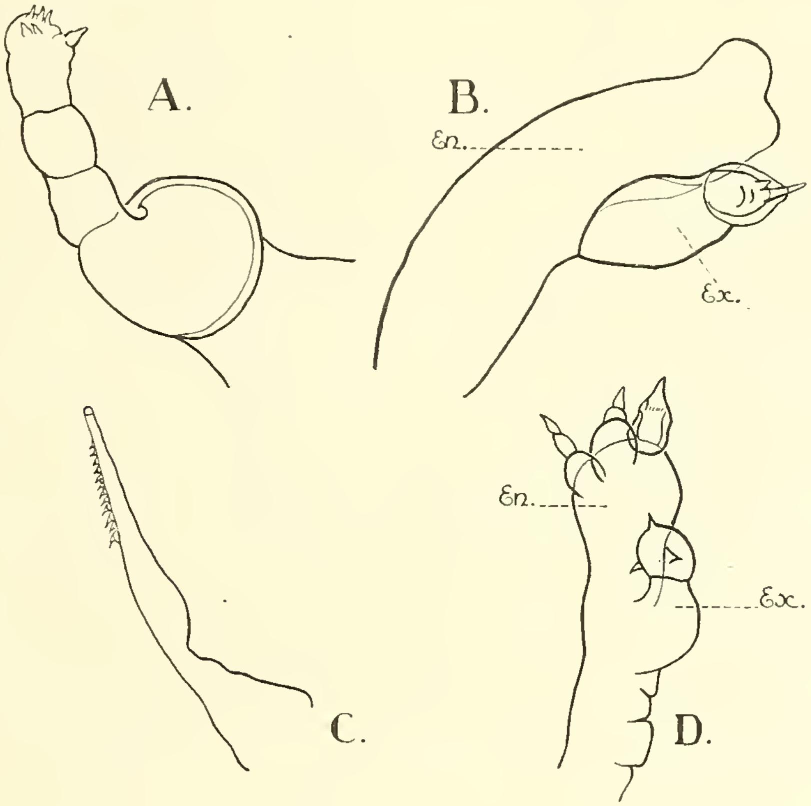

Fig. 3. *Lernaeopoda scyllicola.* The appendages. A, the first antenna, or antennule; B, the second antenna: *Ex.* the exopodite, *En.* the endopodite; C, the mandible; D, the first maxilla: *Ex.* the exopodite, *En.* the endopodite.

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[1] In *L. galei*, Wilson in one place gives the 2nd maxillae as long as the trunk, but most of the authors cited in the references give two-thirds the length of the trunk.

play of movement around this fixed centre which is performed by the maxillipedes.

The bulla or button is derived from a hardened secretion of the frontal gland; it is shaped like a collar stud whose upper surface is concave or pateriform, and indeed its function is a somewhat analogous one. Its details are pretty, and, as far as I know, have not been figured for any species previously.

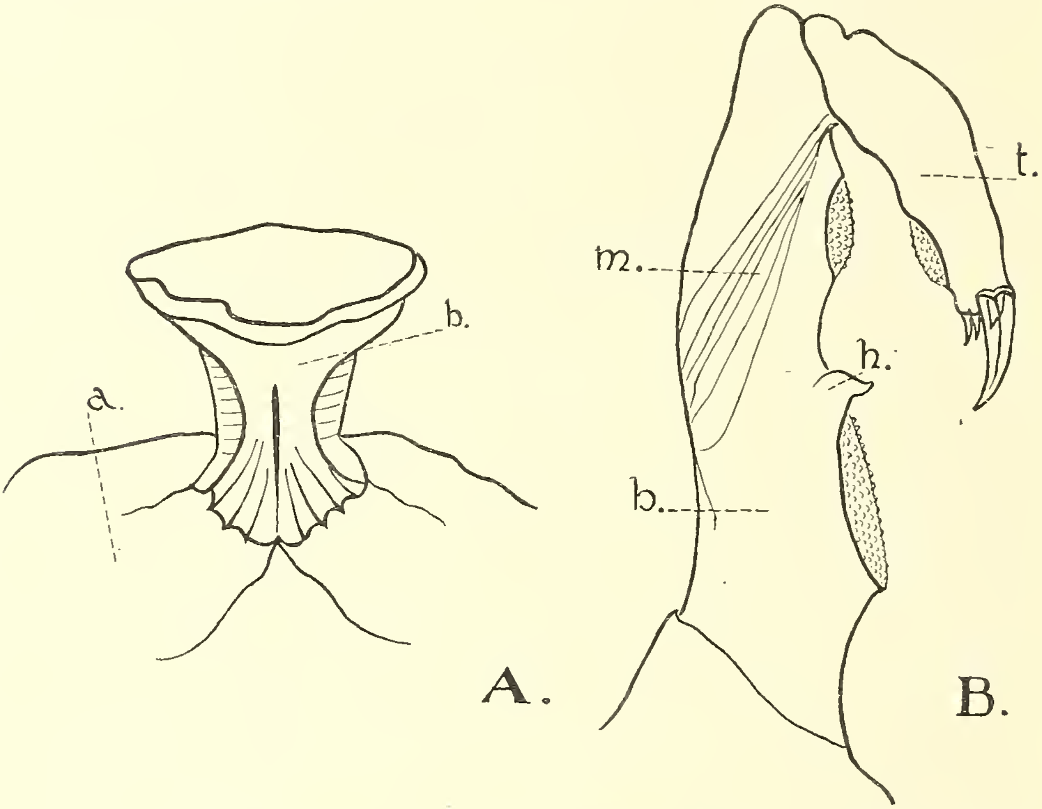

Fig. 4. *Lernaeopoda scyllicola.* The appendages continued. A, the distal ends of the second maxillae under a high magnification; *a.* the swollen tips of the maxillae, *b.* the bulla. B, the maxillipede; *b.* basal joint, *t.* terminal joint, *m.* muscle, *h.* hook.

The *Maxillipedes* (Fig. 4 B) are clawed appendages situated between the bases of the 2nd maxillae (Fig. 5), and consist of a basal joint well supplied with powerful muscles which move the terminal clawed joint, and flex it down against the inside of the basal joint, which is long and slender and provided on the inner side with two rounded cushions covered with papillated spines. Between these cushions is *a large curved hook* (absent in *L. galei* where the basal joint is stout). The terminal joint is rather slender and terminates in a long, abruptly-curved claw with an accessory claw at its base ventrally and two smaller claws at the base on the side of the concavity. Near the end of the terminal joint there is also a rounded cushion of papillated spines, which, when the joints are brought together, would be nearly, but not quite, opposite the more distal cushion on the basal joint. The maxillipedes have lost their function of attaching organs, and are used only for pulling the head down to the skin of the host and holding it while the parasite feeds.

The **Mouth parts.** (Fig. 5.) The mouth is tubular and forms a suctorial proboscis attached between the bases of the second antennae. It is situated at the summit of a cone, and is directed downwards and forwards against the skin of the host. There is an upper and a lower lip each of which is bordered by numerous setae of characteristic shape. The lips are loosely joined along their sides to form a tube by the split edges of the lower lip overlapping the edge of the upper on either side. In Fig. 5 the lips are shown separated. The under lip is the larger and more spoon-shaped so that its anterior end is curved like a horseshoe.

The **Alimentary canal**, like that of many parasites, is degenerate and presents no special features. No glands appear to be present so that digestion is probably intra-cellular. The anus is not covered by plates or lamellae. I have always found the alimentary canal practically empty. Presumably the animal feeds on the soft tissues of the host which is not protected in the extra-cloacal aperture by the well-known dermal denticles. The pads of spines on the maxillipedes are well adapted for rasping any parts of the host, though these appendages are probably used for closer attachment of the head during feeding.

The **Reproductive system** consists of a pair of ovaries on either side of the alimentary canal. These are seen full of eggs. Besides which, as is usual in the Copepoda, the eggs descend into *ovisacs*, or egg-sacs (Fig. 2), which are situated *dorsal* to the genital processes and are long and slender, of equal length with or at least five-sevenths the length of the trunk. The eggs are large and flattened to the form of oblate spheroids. There are in the ovisacs usually four to six rows of 22 or 23 eggs each[1].

The oviducts leave the ovaries about half-way down on their outer borders. The *Cement glands* are large and crescentic and are attached to the oviducts on their inner sides very close to their origin from the ovaries. The walls of the cement glands are striated and must contain muscle fibres. Only the terminal portion is glandular, the remainder of the organ being used for the storage of the cement substance until the eggs are ripe. The cement gland opens into the oviduct just before it bends sharply in a posterior direction. The oviducts open on the

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[1] This appears a very average condition, and agrees with Scott's figure of *L. galei*, while Wilson gives four to six rows of about 150 eggs in each string in *L. galei*, at the same time stating that the ovisacs are as long as the body.

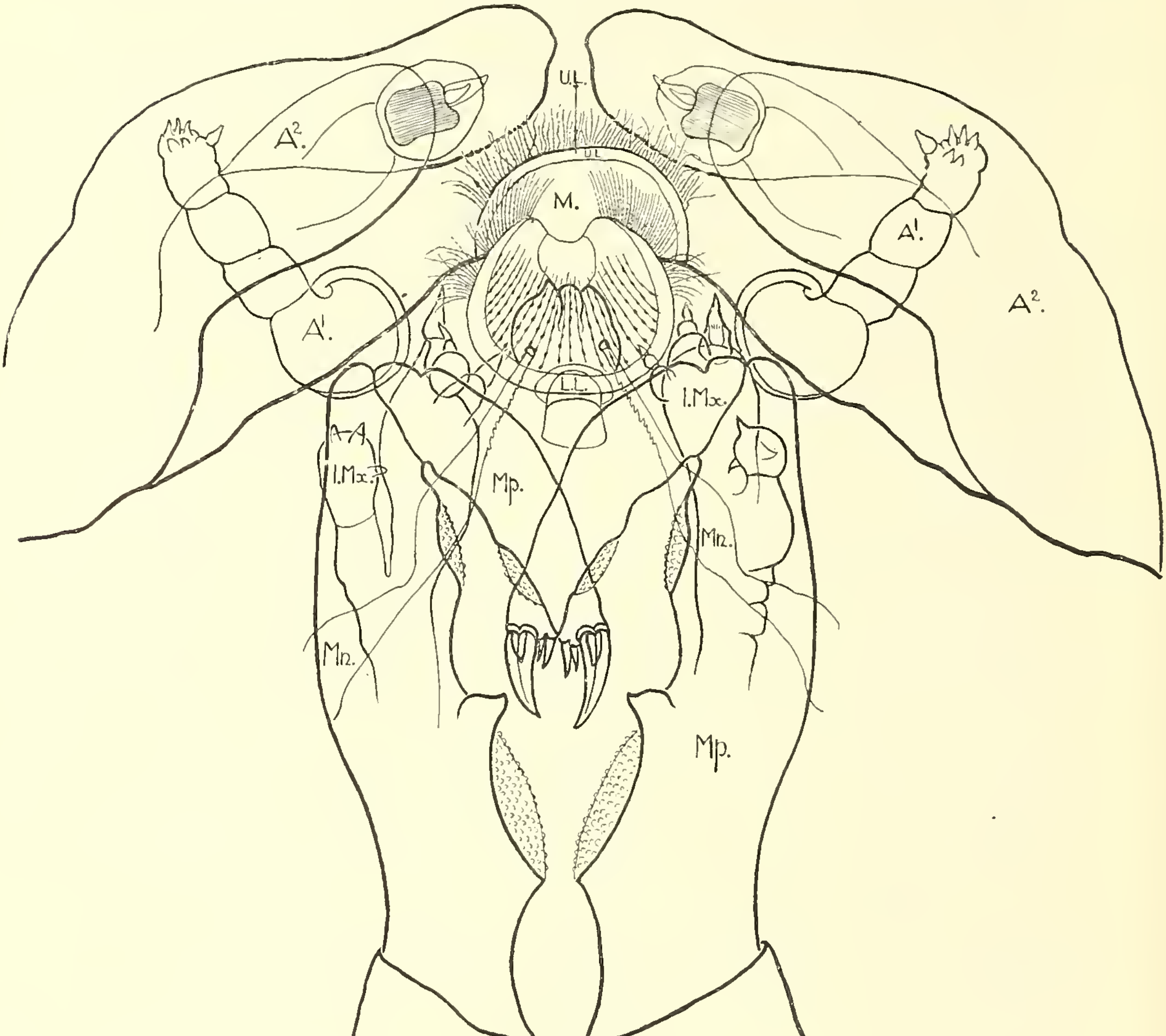

Fig. 5. *Lernaeopoda scyllicola.* The anterior end of the animal showing the mouth parts and some of the appendages *in situ.* A^1. antennule; A^2. antenna; 1.*Mx.* first maxilla; *Mp.* maxillipede; *Mn.* mandible; *M.* mouth; *U.L.* upper lip; *L.L.* lower lip.

inner side of the middle of each half of the abdominal genital segment (Fig. 6). The ovisacs, which are merely strings of eggs embedded in the cement substance, arise immediately over the oviducal orifice. Fertilisation is effected by the passing of spermatophores through a pair of openings called the *vulvae*, situated near the middle line on either side of, and at about the level of, the anus. These openings lead into a curved tube on either side which is very narrow at its origin, and which gradually broadens out to serve as a *spermotheca*, the broad end being in open communication with the oviduct at or near its external aperture in such a way as to allow the eggs to be fertilised as they pass into the ovisacs.

The spermothecae once filled with spermatophores by the male probably contain enough spermatozoa to fertilise all the eggs laid by the female during her lifetime. Only once have I found a female not carrying ovisacs, and this probably as the result of accident, and not because it was immature, for the ovary contained a full complement of eggs. I consider it most probable that the eggs undergo practically complete development in the egg-strings where they are afforded a sufficiently safe protection. The time when the metanauplius stage is ended coincides with that of the disintegration and dissolution of the "cement" covering, as in the case of the albuminous envelope surrounding the spawn of a frog; and at that moment the ovisac vanishes and the larvae swim away freely from the mother into the sea. Almost immediately, in my opinion, a fresh consignment of ova is liberated from the ovary, being fertilised on passing out (with a fresh store of cement which actually precedes and surrounds the eggs) by spermatozoa stored already in the spermothecae. It may be that the sacless female I observed was caught precisely in the interval between the dissolution of the ovisacs and the escape of one brood, and the formation of the next. Unlike *Cyclops* the mother does not part with her ovisacs upon sudden immersion into alcohol, formalin, or fixative, which is a point against their loss being attributed to accident. Again, in this isolated case, the ovary was almost completely full of eggs, while usually that organ presents spaces, as shown in Fig. 6, which were presumably filled by the ova now descended into the egg-strings.

Precisely why male dogfish are selected by the free-swimming larvae as hosts rather than females is not clear. Perhaps it may be due to there being far more room and convenience in an extra-cloacal aperture kept open by the claspers. Moreover it would seem to be actually disadvantageous for the parasite to be situated on the clasper itself (albeit *Lernaeopoda bidiscalis* is always stated to be found on the *tips*, not grooves, of the claspers of *Galeus vulgaris*), as the animal would be liable to be torn off during the copulation of the hosts.

Generic characters ♀. Maxillipedes inside of the second maxillae and close behind the mouth tube. Second maxillae much longer than the cephalothorax which is separated from the trunk by a neck, and which bears a distinct dorsal carapace. No anal laminae. Genital process minute. Abdominal appendages ventral to the ovisacs.

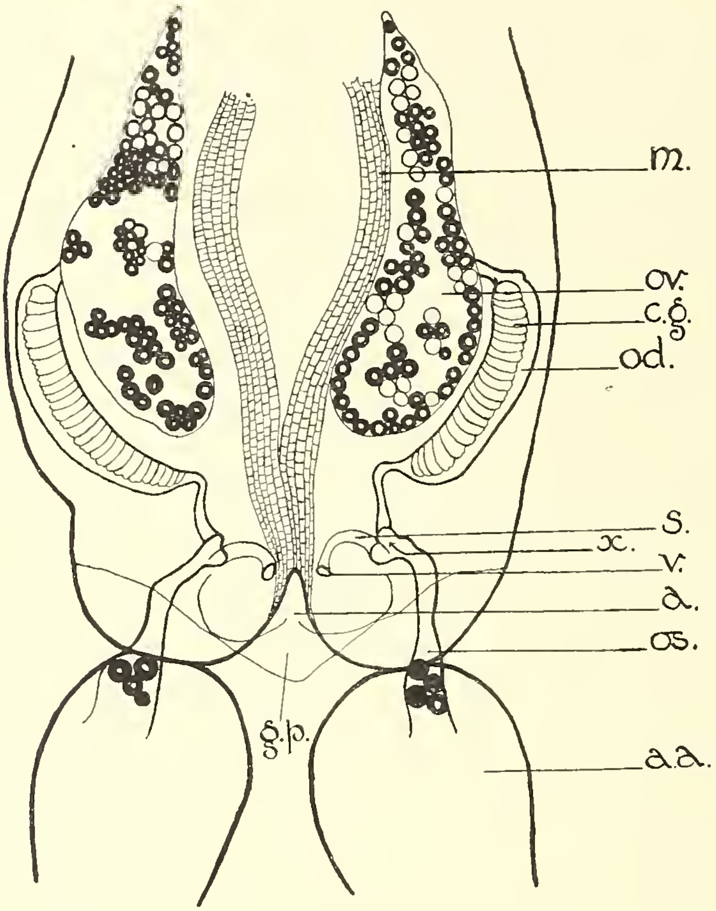

Fig. 6. *Lernaeopoda scyllicola.* The posterior end of the trunk in ventral aspect showing anus (*a*) without lamellae, the minute genital process (*g.p.*), and the reproductive system. *m.* muscle; *ov.* ovary; *c.g.* cement gland; *od.* oviduct; *os.* ovisac; *v.* vulva; *x.* origin of ovisac, the oviduct opening above and the spermotheca below; *s.* spermothcea; *a.a.* abdominal appendage. The ovisacs are shown cut off short.

Specific characters ♀. The ends of the second maxillae are swollen, as long as the trunk and united to a bulla of characteristic shape. The thorax alone shows traces of segmentation. The abdominal appendages are large, and three-sevenths the length of the trunk. The mandibles differ from those figured of any other species, being much more slender, aciculate with minute sharp-pointed downward-pointing teeth, while at the base of the blade is a flat triangular plate. The maxillipede is especially characteristic, the terminal joint being slender, and the basal joint having a peculiar hook-like projection between the cushions of spines. Ovisacs usually of the same length as the trunk.

This investigation was carried out at the South-Western Polytechnic, Chelsea, London, S.W. My thanks are due to Mr J. T. Cunningham for his kind help and to Mr F. Maurice-Rey for reproducing the figures from my sketches.

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PLATYBDELLA ANARRHICHAE.

WITH A NOTE, ERRATUM, AND AN APPENDIX.

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(With 11 Text-figures.)

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Platybdella Anarrhichae. (Diesing 1858, as defined by Malm 1863.)

Introduction. In a previous paper (1914, p. 217) I gave, in tabular form, the features which serve to distinguish the two genera *Calliobdella* van Beneden and Hesse 1863, and *Trachelobdella* Diesing 1850, which Johansson 1898, pp. 672–675 has also given reasons for distinguishing.

Immediately after the publication of my paper I learned through Mr T. J. Evans of Guy's Hospital Medical School that Dr Herbert Henry, when in Scottish waters, had repeatedly found a leech alleged to be *Trachelobdella* on the gills of *Anarrhichas lupus.* Henry concerned himself with *Haemogregarina* occurring in this fish, and the leeches he found were determined by Miss Muriel Robertson as probably *Trachelobdella lubrica* Grube 1840 (*vide* Henry 1912, p. 195).

I have since received, through the courtesy of Prof. D'Arcy Thompson, some dozens of leeches taken from *A. lupus* and collected by Dr Alexander Bowman of Aberdeen. These leeches proved to be

Platybdella anarrhichae (Diesing 1858)[1] as defined by Malm 1863, and not *Trachelobdella* as would have been expected in view of the above statement that Henry had found *T. lubrica* (?) commonly on the catfish.

Habitat. *Platybdella anarrhichae* is parasitic on *Anarrhichas lupus*, the wolf-fish or catfish, on the gills, the walls of the branchial chamber, and has been found on the pectoral region in general, both on young and adult fish, in enormous numbers. It continues to live for days after the fish are dead and gutted and packed in ice. Dr Henry tells me he has found a single specimen of the leech (if the same) on an adult *Cottus bubalis* taken at Robin Hood's Bay. The leech is frequently found on the shores of Scotland, but it is much rarer on the eastern shores of the North Sea, *i.e.* in Norway, according to Johansson.

Body. The body of the leech is cylindrical, only moderately depressed, without papillae or respiratory vesicles, divided, though not very distinctly, into an anterior "neck," and a posterior abdomen. The animal, when at rest, does not curl itself up. The posterior part of the body is but little broader than the anterior. There are no eyes. The skin is extraordinarily smooth, but when the leech is alive and on the host the skin is more wrinkled (Hesse). The annuli can only be made out with difficulty. The colour of the animal is pale grey, or greyish white, bordering on yellow with reddish streaks fore and aft, but more noticeable posteriorly. To my mind these red streaks are caused solely by the colour of the oxyhaemoglobin of the ingested blood of the host in the digestive tract being visible through the skin, which is remarkably diaphanous, the internal organs being most easily observed through it in a mounted specimen. Greenish spots appear here and there. The *average* length of my spirit preserved specimens, which still show plainly the reddish streaks, is 2·5 cm., showing that they attain a length of 3 or 4 cm., as stated in various reports, and a width of about 2 mm.

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[1] This is probably the same leech as that described as *Ichthyobdella anarrhichae* (Diesing) by van Beneden and Hesse, and most certainly the *Platybdella anarrhichae* described by Malm. The diagnosis given by Diesing is so vague that I should hesitate to recognize a specimen from it, whereas the leeches are easily identified from the text of Malm, and particularly from the figure. Blanchard does not mention *Platybdella* except as a synonym for *Cystibranchus* (*Cystobranchus*), which it obviously is not in the now-accepted definition of the latter genus. *Platybdella* is not particularly flattened, hence the name is a misnomer. The facts of the case are that the animal now known as *Cystibranchus mammillatus* was a *Platybdella* according to the loose diagnosis of such authors as Diesing and Malm: hence Malm's definitions have had to be in this case considerably amended.

Suckers. The anterior sucker is cupuliform and distinct from the body, having the mouth at its centre. Here I should like to emphasize the difference between this type and that described as hood-like, as in *Calliobdella*. The anterior sucker is scarcely as broad as the body at its broadest part. The posterior sucker is also cupuliform and twice as broad as the oral (or anterior) sucker. The margins of both suckers are entire. In a certain percentage of my specimens, and in those of others, the margin of the anterior sucker appears crenated as I have shown in Fig. 8; this, however, I am certain is a post-mortem effect and does not constitute a specifically different feature (*vide* Diesing 1858). The posterior sucker is folded under the abdomen. Both suckers are whiter than the rest of the body. Fig. 8 C represents a very life-like position.

Segmentation and Annulation. The skin appears to the unaided eye perfectly smooth. Under the microscope the annuli appear to be very numerous and very small. There is great difficulty in counting the annuli and deciding how many constitute a segment. We do not know how many annuli compose a typical or abdominal segment. The animal may, however, be divided into the usual regions as follows, the number of segments and annuli being stated *tentatively*. The notation is given in Fig. 1.

a. *Anterior sucker.*

b. Three small annuli, occupying the same situation as similar ones in *Calliobdella lophii.*

c. The *Preclitellum.* It is difficult to tell here which are complete annuli, and which are subdivisions by chorisis, either complete, or only extending partially across the annulus. There appear to be **11** annuli, all of which, except the first few, are subdivided, perhaps completely, but more probably only partially and superficially by chorisis. (If there are 11 annuli it is a coincidence that this region comprises the same number as in *Calliobdella lophii.*)

d. The *Clitellum* consisting of **3** segments. The first two are large, the third small. The first and second segments bear the male and female genital apertures respectively. The clitellum is divided from the abdomen by a marked line which appears dark and distinct under the microscope when viewed by transmitted light, in a preparation cleared in oil of cloves. Whereas there is a slight constriction in a mounted specimen, there is no noticeable cincture or differentiation in the living leech.

e. *Abdomen. Testis region.* **6** segments.

f. *Abdomen. Caecum region.* **6** segments probably.

g. *Anal region.*

h. *Posterior sucker.*

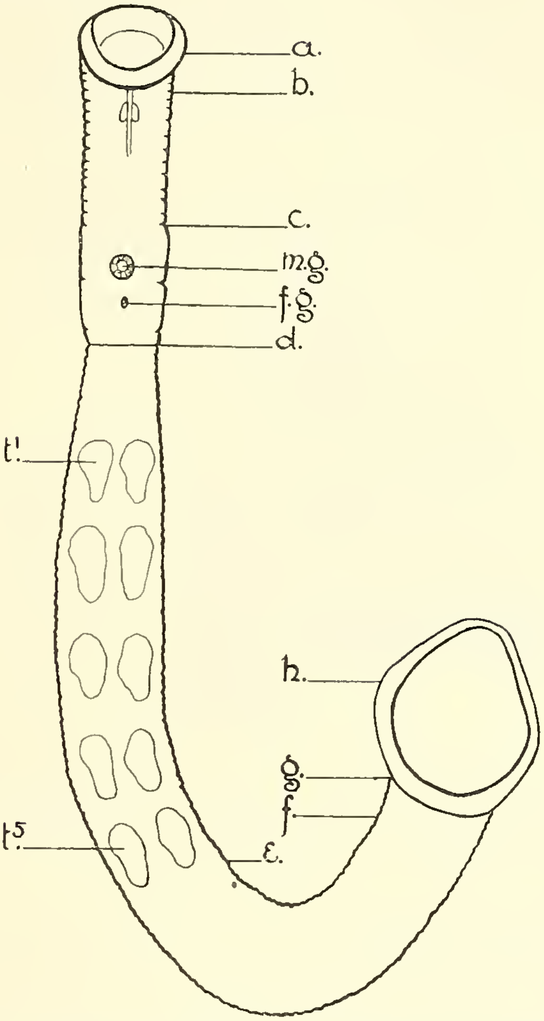

Fig. 1. *Platybdella anarrhichae.* The entire animal viewed from the ventral surface. An unstained balsam-mounted specimen. Lettering as explained in the text. *m.g.* male genital aperture; *f.g.* female genital aperture; t^1, t^5 the first and last apparent pairs of testes.

Nervous System. The ventral nerve cord resembles that of other Ichthyobdellid leeches, and lies within the ventral sinus.

Coelom. The body cavity is divided into the five following parts: a ventral sinus (containing a blood vessel), a dorsal sinus (containing a blood vessel), two lateral sinuses, and, in parts, an intestinal sinus, as shown in Fig. 4.

Body Wall. The *epidermis* consists of a layer of cells elongated in a direction at right angles to the long axis of the body, having their nuclei away from the external border, and a cuticle secreted at the free edge. The *derma* is rich in large flattened cells 40 μ in length and half as thick, which however are unlike those of *Abranchus* in being situated immediately outside the muscle layer, where they form a continuous layer. Their nuclei are very large and flattened in the same manner and direction as the cells, 20 × 10 μ in diameter. Outside this cell layer is a thick layer of connective tissue which includes very small fibre-forming cells (Fig. 2). Pigment cells do not occur, but the above-mentioned large cells occupy the place and position of the large pigment cells which occur in *Calliobdella* and other genera, and possibly, even probably, are homologous with them. *Platybdella* differs from *Abranchus* in that in the latter genus these large cells take up practically the whole space between the muscle layer and the epidermis, so that the connective tissue layer is naturally suppressed. A striking feature of this leech is the cocoon gland cells situated beneath the muscle layer. They are of even greater size than the dermal cells already mentioned. They shine through the layers of the body wall in a whole specimen, unstained, but mounted in balsam, appearing as glistening white objects.

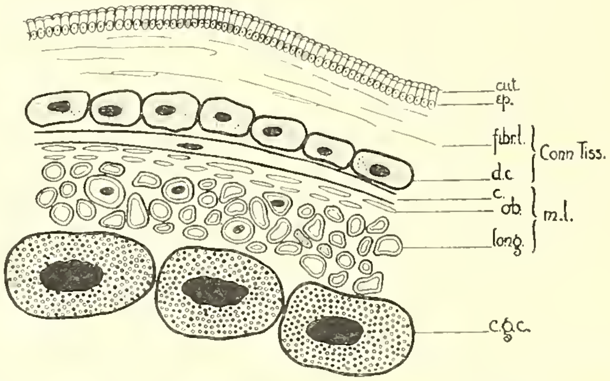

Fig. 2. *Platybdella anarrhichae.* Transverse section of the body wall much magnified. *cut.* cuticle; *ep.* epidermis; *conn. tiss.* connective tissue; *fibr.l.* fibrous cell layer; *d.c.* large subdermal cells, in this case not pigment cells; *m.l.* muscle layer (*c.* circular; *ob.* oblique; *long.* longitudinal); *c.g.c.* cocoon gland cell.

The Cocoon glands. These glands, which occur in most Hirudinea, however nowhere in such development as in the Ichthyobdellidae, open always on the clitellum; wherefore they were called by Bourne (1884) clitellar glands. He states that in *Piscicola* they are "very extensively developed," which is equally true for most, if not all, of the remaining genera, the glands extending from the end of the clitellum to the anus forming a continuous layer underneath the sub-dermal muscle layer. The glands are formed of spherical cells elongated in the direction of the body length; these cells are always large and may attain colossal dimensions. In *Abranchus brunneus* Johansson has measured cells up to 250 μ by 100–150 μ. They are of about this size in *Platybdella anarrhichae*, *Calliobdella lophii*, and, according to Johansson, in *Abranchus microstomus* also, while in the remaining species they are smaller, namely from 50–100 μ. The clitellar cells include a very large nucleus, usually of irregular form, and provided with numerous nucleoli. The nucleus is surrounded by numerous granules which stain as deeply with haemalum as does the nucleus itself, and which, previous to the

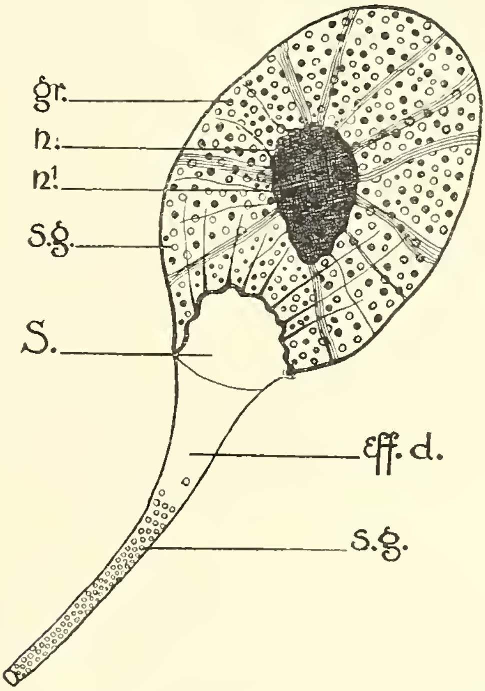

Fig. 3. *Platybdella anarrhichae.* A cocoon gland cell very much magnified. *n.* nucleus; n^1. nucleoli; *gr.* stainable granules in the cytoplasm; *S.* a hollow part of the cell full of collected secretion; *eff.d.* efferent duct; *s.g.* clear granules afterwards found in the secretion.

act of secretion, and particularly in specimens caught in winter or in the early part of the year, appear on this account so numerous as to give to the cytoplasm a uniformly dotted appearance. The secretion which is given off fills ultimately a large part of the cell, and seems within the cell as well as in the greater part of the efferent duct *not* completely homogeneous; near to the commencement of the duct it shows itself granular. The nuclei, according to Johansson, are ultimately destroyed whereby the secretory power of the gland comes to an end. He bases this conclusion on the fact that old individuals possess numbers of such exhausted cells among the functional ones. Such enucleated cells were not found in any of the leeches sectioned

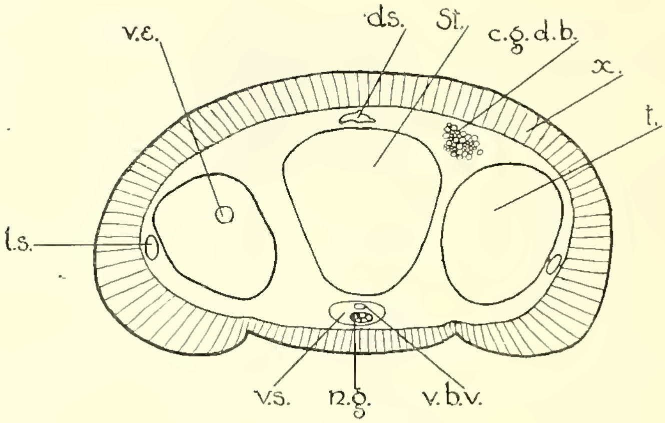

Fig. 4. *Platybdella anarrhichae.* Transverse section of the leech in the anterior portion of the abdomen. *St.* stomach; *t.* testes; *c.g.d.b.* cocoon gland duct bundles beginning to scatter; *d.s.* dorsal sinus; *v.s.* ventral sinus; *l.s.* lateral sinus; *v.b.v.* ventral blood vessel; *n.g.* ganglion on ventral nerve cord; *v.e.* vas efferens; *x.* body wall. The shaded part includes the whole of the layers shown in enlarged detail in Fig. 2.

by me, but I understand that Dr Henry has found them in his specimens. The cells exhibit the curious phenomenon of unicellular glands. The efferent ducts of the cocoon gland cells, which naturally increase in length according to the distance of the gland-cell from the clitellum, are wide just at the border of the cell from which they spring (Fig. 3), but quickly narrow to fine tubes which run forward without winding until they come to the clitellum (Fig. 4). Here they bend more or less at an angle from their original direction, perform several windings, and open thereupon on the whole surface of this region, except a little circle surrounding the genital openings. The apertures of the ducts are extremely fine. The efferent ducts do not, however, run forward independently one from another without arrangement, but are collected into close bundles which, as well in number as in position, are, in most cases, constant in the same species. They can generally be distinguished a little in front of the anus. Afterwards the bundles increase in breadth through the addition of more ducts, until in the neighbourhood of the clitellum they are divided up into several, and in the clitellum into entirely separate bundles with single ducts.

The investigation of these cells was undertaken and first adequately described by Johansson in *Abranchus brunneus*, and afterwards they were independently examined by Dr Henry, who did not publish any account, with Mr Evans, in the leech from *Anarrhichas lupus* which I am assuming throughout is *Platybdella anarrhichae.* Subsequently I have re-examined the whole matter, and am able to confirm their work as I have described in the foregoing account. I must however mention that Johansson considers the secretion to be at first completely homogeneous, but I can easily trace the course of the ducts among the muscles by means of their clear granular contents as shown in Fig. 5. These clear granules are already plainly visible in the cytoplasm of the gland cell at the beginning (Fig. 3), so cannot be deposited or precipitated in the secretion later. Johansson mentions that the number and position of the bundles in every species of Ichthyobdellid leech that he has examined (which does not appear to include *Platybdella anarrhichae*) is constant with two exceptions, *Piscicola* and *Abranchus brunneus*, and all the species show a complete similarity in this respect. The normal condition

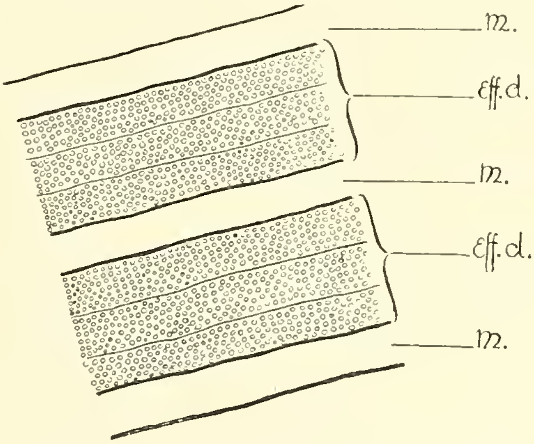

Fig. 5. *Platybdella anarrhichae.* Longitudinal section very highly magnified showing how the efferent ducts of the cocoon gland cells (*eff.d.*) run with the longitudinal muscle fibres (*m.*).

appears to be eight adradially arranged bundles, that is to say, two dorsal, two ventral, and two lateral on each side. Near the clitellum they break up into twelve or sixteen or even more bundles. In *Piscicola* the bundles are four in number and interradial in position. Near the clitellum, at a shorter or longer distance, the bundles are usually divided into four adradials. But in *Abranchus brunneus* numerous small bundles lead forwards without any definite arrangement wherever they have room. From my observations this appears to be the case also in *Platybdella anarrhichae* (Fig. 4 *c.g.d.b.*), where the ducts, often in threes, run interspersed with longitudinal muscle fibres (Fig. 5). There are naturally eight spaces where mixed collections of ducts and muscles can run, two dorsal (one of which is indicated in Fig. 4), two ventral on either side of the ventral sinus, and two lateral on each side above and below the lateral sinusus. But, far from calling these eight bundles, I consider them as ducts running forwards among the muscle fibres wherever they have room. I desire to lay stress on the considerable resemblances between *Platybdella* and *Abranchus* noted in this paper, which might lead to their inclusion under one generic name.

Digestive System. The mouth is situated at the centre of the anterior cupuliform sucker, and the anus opens on the dorsal side between the last and last but one of the annuli immediately preceding the posterior sucker. There is an oesophageal bulb or pharynx into which opens a pair of well-marked salivary glands. The alimentary canal is straight, and of very nearly the same calibre throughout its length, while its walls are exceedingly thin, so that the contents can be easily seen, which gives the leech its reddish markings. The contents of the canal are always abundant, and consist of bright red nucleated blood corpuscles from the gills of the host. Van Beneden and Hesse state that there are no caeca, but this, however, is not the case. There is the usual single pair of caeca, ventral to the intestine, which cohere in *four* places, being the second stage in the development of cohesion from the primitive pair of caeca, and figured in my paper on *Calliobdella* (p. 214, Fig. 5 *c.* q.v.). Here there are connections not only in the sixth and fifth segments of the abdomen (as in *Abranchus microstomus*), but also in the fourth and third, thus only a short piece is unfused. I find that the food, *i.e.* blood corpuscles, tend to collect in these cross connections, which are obviously in a direction at right angles to the body axis, and these give to the animal the appearance of reddish streaks to which allusion has already been made (Fig. 6).

Reproductive System. The position of the genital openings on the clitellum has already been stated (Figs. 1 and 8 A). The *male* reproductive organs consist apparently of *five* pairs of metameric testes situated in segments two to six of the abdomen, instead of six pairs as is usual in the Ichthyobdellidae. Johansson writes: "only in *Abranchus* is there a smaller number" than six "observed constantly. I have never observed more than five pairs in this genus, and in *A. brunneus* sometimes not more than four pairs situated in the *first* four or five segments" (of the abdomen). "Often I have observed in this genus, as in others, that one testis of a pair can be absent but one finds, on anatomical investigation, a trace thereof in the form of a little cavity, and usually one even sees a trace of the corresponding vas efferens."

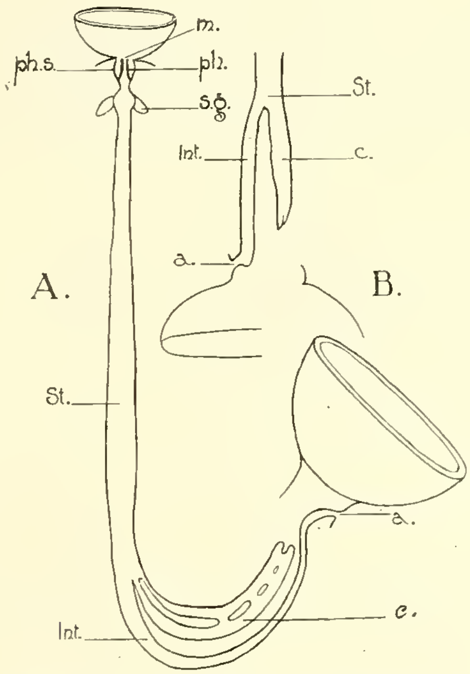

Fig. 6. *Platybdella anarrhichae.* *A*, scheme of the digestive system, partly from the ventral aspect, to agree with Fig. 1, showing the natural position of the posterior sucker flexed under the abdomen. *m.* mouth; *a.* anus; *ph.* pharynx; *ph.s.* pharyngeal sheath; *s.g.* salivary glands; *St.* stomach; *c.* caeca (ventral); *Int.* intestine; *B.* the posterior end of the same, lateral aspect.

Van Beneden and Hesse state that in *Platybdella* (*Ichthyobdella*) *anarrhichae* there are five pairs of testes.

I have previously remarked on the extraordinary transparency of the skin of this animal, so that the cocoon gland cells are visible through it, and also the testes, which are unduly large and prominent in proportion to the width of the abdomen. In the leech mounted in balsam as a transparent, unstained, microscopic object five pairs of such, large, white, glistening, pear-shaped, obviously-chambered organs can be easily seen, though, while being equidistant from each other, there is considerable space between the first pair thus seen and the post-clitellar cincture. Thinking that van Beneden and Hesse might well have overlooked the first pair in their dissection, and that Johansson was not likely to be wrong, I. cut transverse and longitudinal sections of a good many leeches but failed to discover any trace of a first pair of testes; what I did discover, however, is sufficiently interesting, namely, that the space that presumably should be occupied by a first pair of testes was filled by very extensive dilations of the vasa deferentia containing spermatoblasts and spermatozoa in all stages of development, thus functioning as vesiculae seminales (Fig. 11) though not comparable to the structures so named in *Calliobdella lophii*. This enlargement of the vas deferens may possibly account for the abortion of the first pair of testes.

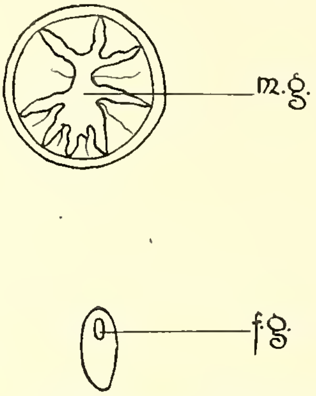

Fig. 7. *Platybdella anarrhichae*. High magnification of the genital apertures. *m.g.* male genital aperture; *f.g.* female genital aperture.

As to whether any trace of a functionless first pair of testes remains, as Johansson suggests it should, I am unable to speak with certainty. On the whole I think not. Only in one case did I notice any body that might remotely resemble one. The specimens were not sufficiently well preserved however to speak positively as to their absence. On the other hand it is not certain that Johansson has examined *Platybdella anarrhichae* on this point, and while in this leech it is the first pair of testes that is reduced or absent, yet, from the purport of his remarks upon the species which he has investigated, Johansson gives us to understand that it is the posterior testes, if any, that are reduced.

Upon fixation the testes may possibly swell; at any rate they occupy so much of the width of the abdomen that the alimentary canal becomes constricted between one pair, and bulged out between successive pairs, and, as the canal is everywhere full of red blood corpuscles, this again contributes to the external appearance of reddish streaks.

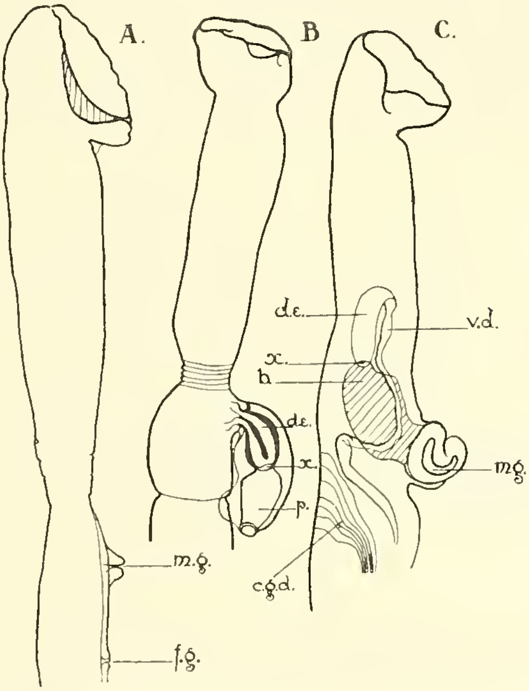

Fig. 8. *Platybdella anarrhichae.* The anterior portion of the animal in lateral aspect. *A*, to show the genital apertures; *B*, with penis extruded; *C*, with penis which has been extruded partially retracted; *m.g.* male genital aperture; *f.g.* female genital aperture; *p.* penis; *b.* bursa; *x.* opening from the ductus ejaculatorii into the bursa; *d.e.* ductus ejaculatorii; *v.d.* vas deferens; *c.g.d.* cocoon gland ducts.

The testes are chambered, each chamber having characteristic wall cells from which are formed the sperm mother cells (spermatocytes). *In no case* in any specimen I have sectioned do the chambers of the testes contain developing spermatozoa, but only spermatocytes. On the other hand the enlarged portion of the vas deferens functioning as a vesicula seminalis (and hereinafter called such for the sake of brevity) contains spermatoblasts, morulae, and fully developed spermatozoa which have just quitted the spermblastophore. The varying stages thus recall those of the earthworm (Fig. 9) with two important exceptions.

In the first place, in some cases sperm development to form morulae does not seem to take place all over the spermblastophore but only to one side of it, the rest being undifferentiated protoplasm; and, in the second, the residual protoplasm of the spermblastophore after the mature spermatozoa have become detached still appears to contain a central nucleus, which, as far as I know, has never been observed in the earthworm. What the significance of this nucleus is, I cannot imagine, since the spermblastophores move down the vasa deferentia towards the ductus ejaculatorii together with the spermatozoa and are presumably ejected with them. The chief point here, then, is that the spermatozoa are *not* developed within the chambers of the testes themselves, but that the spermatocytes pass down the vasa efferentia, and that development takes place solely in a widened portion of the vas deferens, or vesicula seminalis, which occupies the position where one expects to find a first pair of testes.

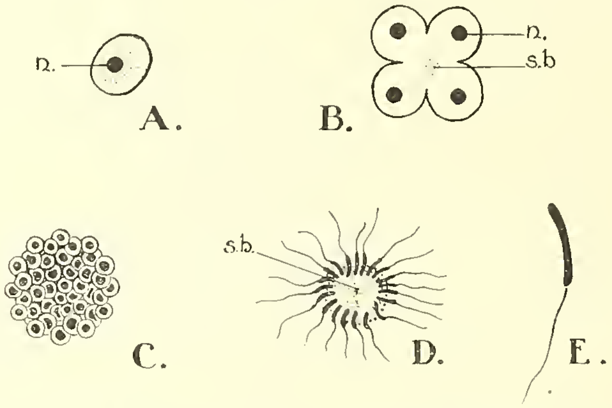

Fig. 9. *Platybdella anarrhichae.* Successive stages in the development of the spermatozoa. *A*, sperm mother cell (spermatocyte); *B*, spermatoblast; *C*, morula; *D*, fully developed spermatozoa; *E*, a single spermatozoon; *n.* nucleus; *s.b.* spermblastophore.

From each testis proceeds a small duct, the vas efferens, there being as many vasa efferentia as there are testes. In this case the vas efferens appears to arise *within* the testis and among its chambers (Fig. 4 *v.e.*). From the posterior testis on each side the vas efferens passes outwards and upwards immediately into the vas deferens which in its course receives the remaining vasa efferentia. After taking up the last vas efferens, each vas deferens dilates enormously to form the vesicula seminalis, and, on arriving at the clitellum, where it narrows, from being ventral, it turns dorsal and afterwards forwards. On arriving at the level of the ♂ genital aperture it makes a half-turn, and passing over the side of the bursa again runs ventrally forwards well into the preclitellum, such an anterior position being somewhat unusual in my experience. Next it turns back completely, running in a posterior direction dorsally, at the same time widening out to form a muscular ductus ejaculatorius. This is best seen in lateral view (Fig. 8 C). The ductus ejaculatorii stretch forward to the anterior border of the clitellum (being themselves in the preclitellum when unextruded), and may be practically said to unite together before entering the bursa by a common opening, so that the common end piece is practically nil, and not as in *Calliobdella lophii.*

The bursa is insignificant, as regards saccular development, but as usual the whole bursa can be everted, and forms a penis capable of standing out a considerable distance from the body. The penis (Fig. 8 B) includes the ductus ejaculatorii in about half its length.

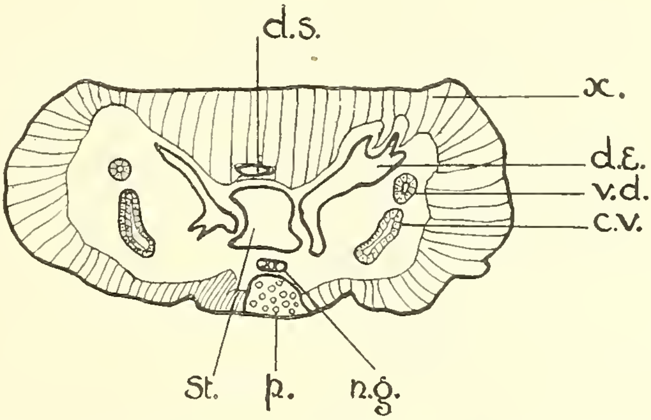

Fig. 10. *Platybdella anarrhichae.* Transverse section of the animal in the clitellar region. *St.* stomach; *d.s.* dorsal sinus; *n.g.* ganglion on ventral nerve cord; *d.e.* duetus ejaculatorii; *c.v.* coiled part of vas deferens; *v.d.* forward-going portion of vas deferens; *p.* penis; *x.* body wall as in Fig. 2 but *without* eocoon gland cells.

A comparison of the relative sizes of the genital apertures in Fig. 7 and of the penis and ♀ genital aperture in Fig. 8 A and B, can only lead to the conclusion that it is impossible, on account of its size, that the penis should enter the ♀ opening. Rather it appears that the penis must be an organ of attachment only (hence perhaps the powerfully muscular ductus ejaculatorii for driving the semen out) after the fashion of that met with in the Mollusca, but hollow. The aperture at the tip of the penis is rather well adapted to *surround* the ♀ aperture which is papillate.

There are no vesiculae seminales in the sense in which this term is used in *Calliobdella lophii.*

The *female* reproductive organs consist of a pair of ovaries, which, unlike those of *Calliobdella*, instead of almost fusing in the median line, are lateral in position. In contradistinction to the testes which are abnormally large, the ovaries are so small that in several of the first leeches I cut they eluded my observation altogether. At first I was inclined to attribute this to the time of year when the leeches were caught (January), yet the same leeches showed an abundance of fully developed and developing spermatozoa in their vesiculae seminales. Some of the leeches when caught had the penis extruded. If copulation takes place at this time of the year, then the presence of true vesiculae seminales would be expected.

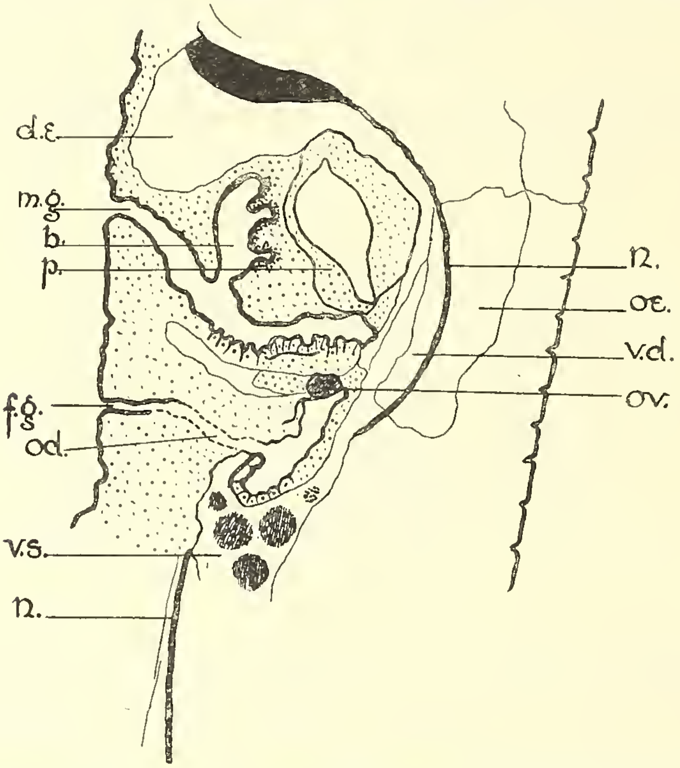

Fig. 11. *Platybdella anarrhichae.* Median longitudinal section through the clitellar region. Diagrammatic since an ovary (which is not median) would not occur in the same section as the female genital aperture. *oe.* oesophagus; *n.* nerve cord; *m.g.* male genital aperture; *f.g.* female genital aperture; *p.* penis; *b.* bursa; *od.* oviduct, the coiled portion represented by dotted lines; *v.s.* vesicula seminalis with developing spermatozoa; *ov.* ovary; *v.d.* vas deferens; *d.e.* ductus ejaculatorius.

The ovary appears as a local development on the wall of a large cavity from which the oviduct arises. It is just possible that this cavity acts as a receptaculum seminis (Fig. 11). The oviducts are somewhat serpentine but can easily be traced and they unite together before arriving at the female genital aperture.

Van Beneden and Hesse (from a dissection, and not from sections) state that they found two uteri full of eggs. In their illustration they figure these uteri in the position in which one finds in this and other Ichthyobdellid leeches the ductus ejaculatorii, which are, of course, full of developed spermatozoa and the large nucleated spermblastophores already mentioned. If they really did find uteri full of eggs, the fact would be in accord with my suggestions concerning fertilisation and development hazarded above; but I think it much more likely, and not unnatural, that what they mistook for uteri were the ductus ejaculatorii, especially in view of their figure.

Generic Characters. Body cylindrical, moderately depressed, without papillae or respiratory vesicles, divided though not very distinctly into an anterior "neck" and a posterior abdomen, very transparent. The leech does not roll itself up when at rest. Oral sucker cupuliform, and of moderate size; posterior sucker obliquely affixed and very distinct. Annuli only made out with difficulty, and the number of annuli to a typical or abdominal somite is still uncertain. Testes apparently only five pairs. Bursa insignificant. Pigment cells absent.

Specific Characters. Anterior sucker scarcely as broad as the body at its broadest part. Posterior sucker twice as broad as the anterior sucker. Eyes absent. Host: *Anarrhichas lupus.*

Methods. The leeches I received from Dr Bowman had been killed in formalin and preserved in spirit. It is notorious that formalin is a bad preservative for histological work, owing, I am told, to the presence of traces of free formic acid. This latter should be got rid of by adding a trace of caustic alkali to the formalin before use. I find it best to slowly anaesthetise the leeches by adding 30 % alcohol, drop by drop, to the water containing them, and when they lie fully extended and uncurled place them in the following hardening reagent, which may be regarded as Zenker with the sodium sulphate left out, or as Tellyesniczky with the addition of corrosive sublimate:

5 g. corrosive sublimate,
3 g. potassium bichromate,
5 c.c. glacial acetic acid,
100 c.c. distilled water.

The leeches are to be left in this solution one or two days, according to size, and afterwards washed in water, and passed through alcohols of increasing strength beginning with 15 %.

The microtome-cut sections, for seeing the cocoon gland cells and other tissues, should be stained as follows:

Haemalum 5–10 mins.
Wash in running tapwater.
Eosin (in 90 % alcohol) 5–10 mins.

If it is not desired to decolorize with acid alcohol the minimum time mentioned should be observed.

For observations of whole unstained specimens in bulk, I find that creosote as a clearing agent on the whole does not act so well as oil of cloves. For one thing creosote is apt to turn pigmented leeches, like *Calliobdella*, black. I do not advocate mounting the entire leeches in Canada balsam; in my experience the internal structure can best be observed in leeches in oil of cloves in a watch-glass. Do not *keep* the leeches in oil of cloves. I preserve my type specimens in a tube of xylol, and transfer them to oil of cloves in a watch-glass for examination.

(My thanks are due to Mr J. T. Cunningham of the South-Western Polytechnic, London, S.W. for his kind assistance, to Mr Gerald Boyce, and to Mr F. Maurice-Rey for reproducing the figures from my rough sketches; the assistance kindly rendered by other gentlemen has already been acknowledged in the text.)

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NOTE.

Calliobdella lophii.

I have to note a specimen of a leech parasitic on *Lophius piscatorius* sent to me by Dr Bowman, having been captured by him on 29. xi. 1910 in the Firth of Forth. This I had no difficulty in recognising as *Calliobdella lophii,* making a further record of this animal's appearance, and on the *same* host.

ERRATUM.

It is agreed, universally I think, that the number of segments in leeches is 34. The reasons for this belief I stated briefly in *Parasitology,* vii, p. 208.

Accordingly in my article on *Ganymedebdella cratere* (*Parasitology,* viii, p. 5, line 26), "37 segments" should read "34 *segments.*" The apparent miscount is due to the divergence of opinion as to the way in which annuli are plotted out in segmentation, it being intended that one of the groups of segments marked with a query should not be considered as segments according to whichever view the reader favours. I am of the belief that in both leeches described in *Parasitology* (vii, p. 206 and viii, p. 4) the three small annuli *a, A, b,* are the ones that will be proved not to be segments in themselves; and subtracting these three from the total, we have the correct number 34.

Dr J. H. Ashworth kindly informs me that *Ganymedes* is a name pre-occupied for a Gregarine (*vide* J. S. Huxley (1910), *Quart. Journ. Micr. Sci.* lv, 155), so that the alternative name of *Ganymedebdella* proposed by me (*Parasitology,* viii, p. 1) will have in future to be used.

APPENDIX.

Key to the ICHTHYOBDELLIDAE.

* typically Northern forms (British waters).
† typically Southern forms (Mediterranean).
†* typically Southern forms but examples have been found in British waters.
‡ fresh-water.
‡‡ some species fresh-water.

Order. RHYNCHOBDELLIDA (RHYNCHOBDELLAE).

Leeches with an exsertile proboscis, without jaws, and with colourless blood.

Family. ICHTHYOBDELLIDAE.

Leeches whose bodies are divided by a more or less marked constriction into a "Neck" (Clitellum and Preclitellum) and a "Body" or Abdomen. The anterior sucker (as well as the posterior) is a permanent adhesive organ distinct from the body. Eggs included in chitinous capsules which are attached to foreign bodies.

Tribe I. *BRANCHIOBDELLINAE.* (Leeches with external respiratory organs. Neck very distinctly marked off from the abdomen by a constriction.)

A. With paired lateral foliaceous branchiae on the abdomen.

(*a*) Parasitic on Testudines, branchiae branched and but few pairs (5).

Ozobranchus.

O. margoi†.

(*β*) Parasitic on fish, branchiae unbranched and many pairs (33).

Branchellion.

B. torpedinis†*.

B. With one row of hemispherical pulsating vesicles on each side of the abdomen.

(*a*) Abdominal segments consisting of 14 annuli. Body spotted with blackish red-brown star-shaped dots arranged in longitudinal and transverse rows. Eyes 4.

Piscicola‡.

P. geometra.

(*β*) Abdominal segments consisting of 4–6 annuli, usually 6. Body spotted with yellow or green-brown scattered unbranched dots. Posterior sucker larger than the anterior. Eyes none.

Calliobdella.

(*a*) Body spotted with yellow dots, posterior sucker twice as broad as the anterior.

C. nodulifera.

(*b*) Body spotted with green-brown dots, posterior sucker four times as broad as the anterior.

C. lophii.

(*γ*) Abdominal segments consisting of 6 annuli. Body without spots, and very depressed. Anterior sucker four times as broad as the posterior and with five muscular bands. Eyes none. Respiratory vesicles 3 pairs.

Ganymedebdella.

*G. cratere**.

(*δ*) Abdominal segments consisting of 7 annuli.

Cystibranchus‡‡ (Cystobranchus).

(*a*) Eyes 4 and a crown of oculiform points on the posterior sucker.

C. respirans†.

(*b*) Eyes none.

C. mammillatus.

Tribe II. *ICHTHYOBDELLINAE.* (Leeches without external respiratory organs. Neck and abdomen scarcely marked off from one another by a constriction.)

A. Skin with large papillae wart-like and arranged in transverse rows all round the body.

Pontobdella.

P. muricata.

B. Skin on the back with six longitudinal series of small warts. Eyes none.

Ichthyobdella.

I. elegans.

C. Skin smooth.

(*a*) Eyes 6.

Abranchus*.

(*a*) Anterior sucker well developed almost as large as the posterior sucker. Body brown, not transparent.

A. brunneus.

(*b*) Anterior sucker very small, formed merely from the edge of the mouth cavity. Body considerably transparent.

(1) Body unpigmented, slightly yellow owing to the gland cells showing through.

A. microstomus.

(2) Body with numerous dorsal transverse black bands interrupted in the middle line.

A. sexoculatus.

(*β*) Eyes 4.
(*γ*) Eyes none. Posterior sucker twice the size of the anterior.
Platybdella*
P. quadrioculata.
P. anarrhichae.*

(*δ*) Eyes none. Body pointed at both ends. Anterior sucker and posterior sucker of about equal size, small, and not as broad as the body at its broadest part. (? One pair of vesicles.)

Hemibdella*.

H. soleae.

A KEY TO HOSTS.

On *Anarrhichas lupus*	*Platybdella anarrhichae*
,, Elasmobranchs, principally species of *Raia*	*Pontobdella muricata*
,, Elasmobranchs, usually *Torpedo*	*Branchellion torpedinis*
,, *Lophius piscatorius*	*Calliobdella lophii*
,, *Solea vulgaris*...	*Hemibdella soleae*
,, *Cottus scorpius*	inter alia *Abranchus brunneus* and *A. microstomus*

NOTES ON TICKS. IV.

RELATING TO THE GENUS *IXODES* AND INCLUDING A DESCRIPTION OF THREE NEW SPECIES AND TWO NEW VARIETIES.

By GEORGE H. F. NUTTALL, F.R.S.

(*From the Quick Laboratory, University of Cambridge.*)

(With 21 Text-figures.)

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[1] The signs ♂ ♀ ○ ∠ denote male, female, nymph and larva respectively.

1. New Species and Varieties of Ixodes.

Ixodes eichhorni n. sp.

Figs. 1 and 2.

Male: Unknown.

Female (Fig. 1): Colour: scutum, basis capituli, coxae, distal parts of femur and proximal portions of tarsi and intervening articles are blackish brown, the remaining hard parts shading to yellowish-brown. (*Dorsal aspect*) Body (partly gorged) short and broad. *Scutum* about as long as broad, 0·87 × 0·85 mm., very slightly emarginated, with rounded scapular angles, antero-lateral borders almost straight, lateral angles situated at the anterior third of the length, posterior border rounded; cervical grooves deep, far apart, but slightly concave outwardly and slightly divergent, fading near the postero-lateral borders; surface glossy, somewhat rugose; punctations few, mostly fine. *Capitulum* with base roughly equilateral-triangular, short pointed cornua and sinuous dorsal ridge; porose areas not depressed, subcircular, near ridge, the interval less than their width and hollowed. Palps slender, article 1 small, articles 1–2 almost fused, broadest at the distal

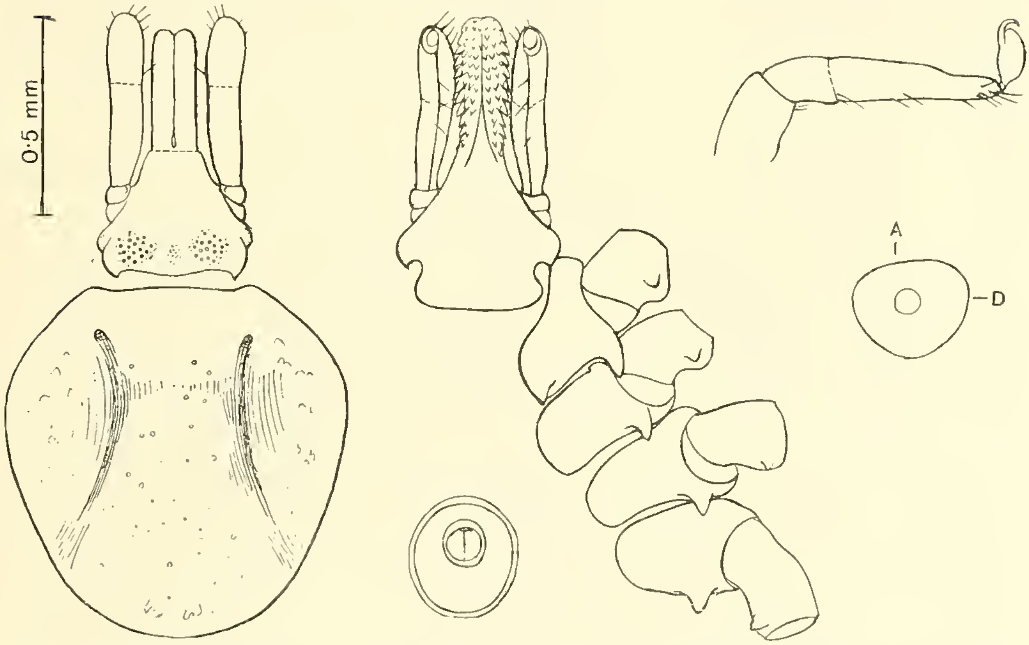

Fig. 1. *Ixodes eichhorni* n. sp. ♀ (N. 2672). Scutum, capitulum in dorsal and ventral aspects, coxae with trochanters, anus with circular anal groove, spiracle and tarsus 4 (G.H.F.N. del.).

third of article 3 which is rounded distally; (*Ventral aspect*) hypostome club-shaped, 4|4 merging to 3|3 and 2|2 posteriorly where the median unarmed ridge broadens, teeth sharp, 12 per external file; basis capituli constricted where the short pointed recurved auriculae arise, posterior margin straight with rounded angles. *Venter*: vulva between coxae II; *anal grooves form a small closed ring* situate near the posterior border; spiracle ovoid, macula central. *Legs* slender; coxa I with short internal and stout external spur; stout external spurs on coxae II–IV progressively decreasing in size; trochanters with slight spurs; tarsus 4 tapering gradually, the distal pseudo-article about thrice as long as the basal; pads large but shorter than the claws.

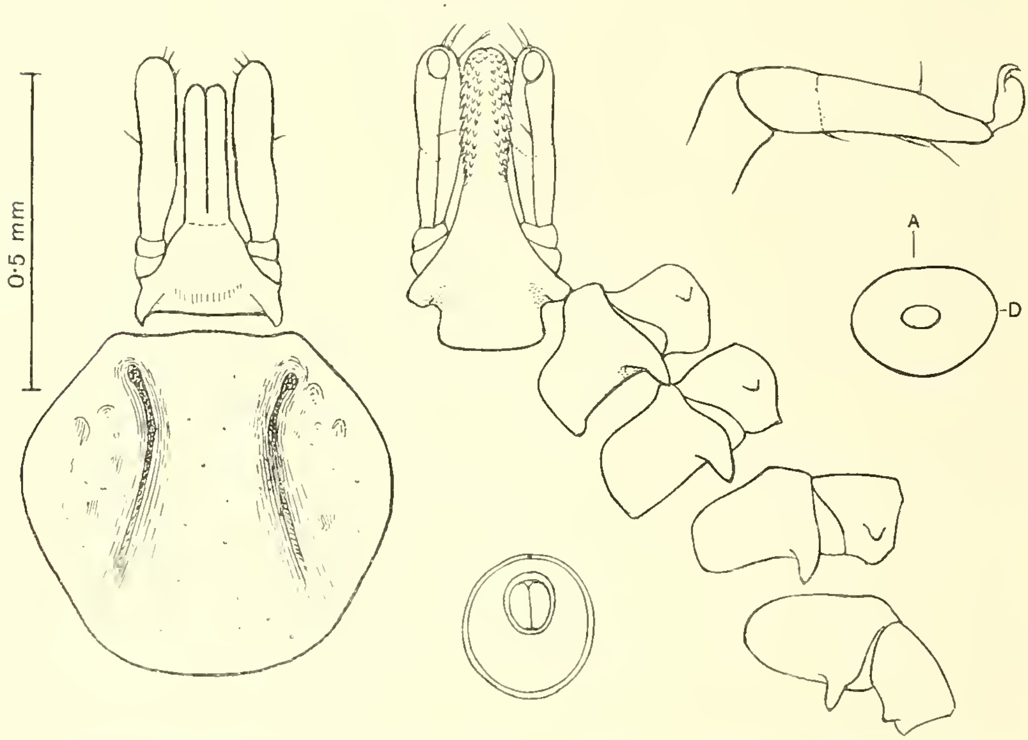

Fig. 2. *Ixodes eichhorni* n. sp. nymph (N. 2675). Scutum, capitulum in dorsal and ventral aspects, coxae with trochanters, anus with circular anal groove, spiracle and tarsus 4 (G.H.F.N. del.).

Nymph (Fig. 2): Resembles the ♀ in general form, structure and colour. (*Dorsal aspect*) Body with a few white hairs posteriorly. *Scutum*: 0·55 × 0·6 mm. with equally marked cervical grooves, the external fields somewhat rugose. *Capitulum* with cornua somewhat more pointed and arising from slight ridges extending over the dorsal surface of the base; (*Ventral aspect*) auriculae well marked but basis capituli narrower posteriorly than in the ♀.

Described from a ♀ found on the *collector's person* at Rook Island, Friedrich Wilhelmshaven, German **New Guinea,** IX. 1913 and several unfed ○'s found on a *Kingfisher*, Manus, Admiralty Islands, IX.–X. 1913 by Mr A. F. Eichhorn after whom the species is named and to whom I am indebted for the specimens. Considering the part of the world they come from and the remarkable agreement in structure between the ♀ and ○ I attribute them to one species although they were collected from different hosts. The only species hitherto known to possess circular anal grooves is *I. rasus* Neumann, 1899, from Africa, which differs from *I. eichhorni* in numerous respects, the coxae being unarmed and trenchant, etc.

The types (N. 2672, 2675) are in Cambridge.

Ixodes victoriensis n. sp.

Fig. 3.

Male: Unknown.

Female (Fig. 3): Hard parts amber yellow, except spurs, cornua, etc., which are chestnut. Body (gorged) 8·5 × 5 mm. (*Dorsal aspect*) *Scutum* about as broad as long, 1·25 × 1·31 to 1·2 × 1·36 mm., with moderate emargination, scapular angles rounded at the tips; cervical grooves broad and distinct, almost straight, but slightly divergent behind and attaining the posterior border; medium-sized punctations evenly distributed. *Capitulum remarkable*, with short broad base, large blunt incurved cornua, arising from ridges which, antero-laterally, bound the depressed area occupied by the porose areas which are of irregular form, far apart; the anterior portion of base forming a concave ridge. Palps with article 1 very large, hollowed inwardly, curving about the chelicerae, with pointed postero-external slightly incurved process; articles 2–3 fused, very broad distally and curved dorsally (see profile in Fig. 3); (*Ventral aspect*) article 1 protruding backward and outward with retrograde pointed process, with a flange protruding ventrally and nearly parallel to hypostome; basis capituli narrowing posteriorly, small blunt auriculae; hypostome arising from a broad base and narrowing greatly to where the first basal teeth occur, very broad distally, dentition 5|5 then 4|4 very fine pointed teeth, about 12 per outer file. *Venter*: vulva facing coxa III (in gorged specimens); anal grooves converging gradually behind (and perhaps fusing in unfed specimens?); spiracle small, transversely oval. *Legs*: coxae narrow, I–IV with stout postero-external spur curved back and progressively inward from I to IV, in the last being directed across body-axis; all trochanters with rounded prominences in lieu of spurs; tarsi very short, the distal pseudo-article but slightly longer than the basal and notched distally (as in some argasids); pads very small.

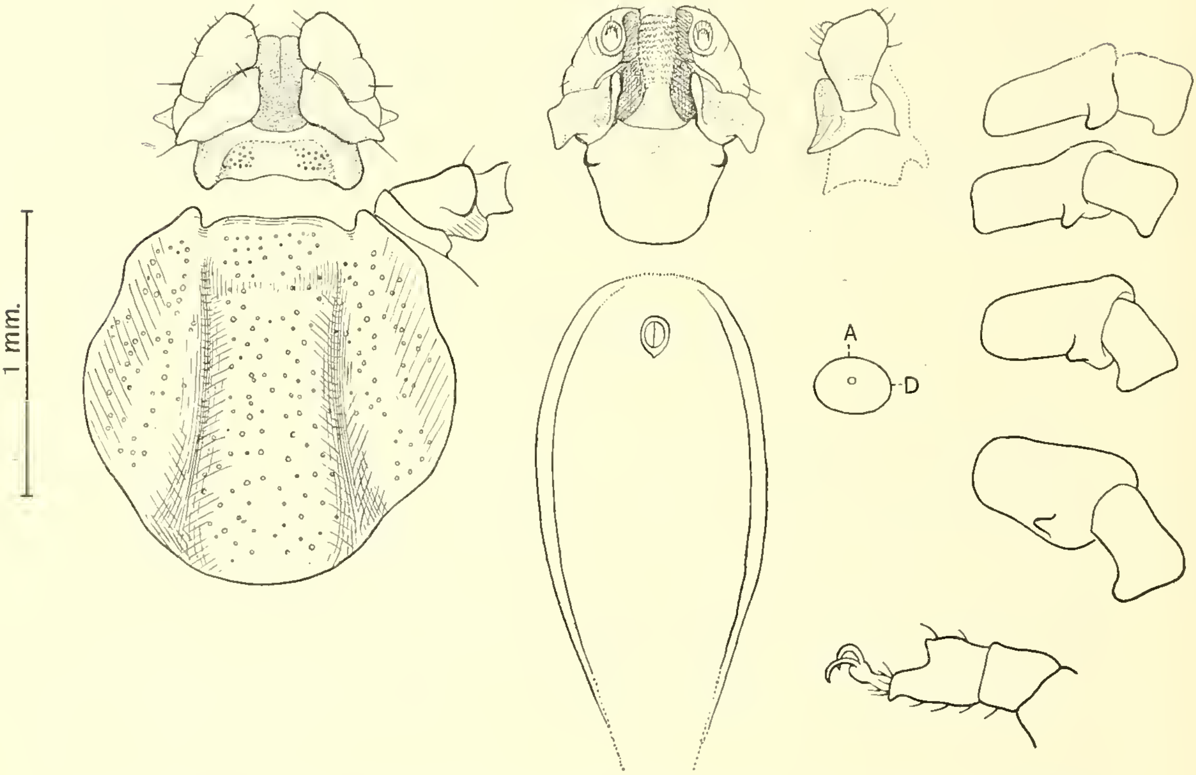

Fig. 3. *Ixodes victoriensis* n. sp. ♀ (N. 3194). Capitulum in dorsal, ventral and lateral aspects, scutum with trochanter and part of coxa I, anal grooves (less magnified than the other parts), coxae with trochanters, spiracle and tarsus 4 (G.H.F.N. del.).

Described from 2 gorged ♀'s from wombat (doubtless *Phascolomys mitchelli*), Victoria, **Australia,** x. 1892, received from Dr Georgina Sweet. The species is allied to *I. australiensis* Neumann 1904 (see *Ticks*, Part II, pp. 250–252, Figs. 247–249) but differs therefrom especially in the structure of the capitulum, scutum, and tarsi.

Types in the collection of Dr Sweet (No. 236*a*), Melbourne, Australia, and (N. 3194) in Cambridge.

Ixodes nairobiensis n. sp.

Fig. 4.

Male: Unknown.

Female (Fig. 4): Hard parts chestnut brown. (*Dorsal aspect*) *Scutum* long oval, much longer than broad (1·26 × 0·8 mm.), with emargination normal, scapular angles pointed, lateral ridges distinct; cervical grooves defined by a depressed area external to them and two oblong depressions posteriorly along their course, not attaining the posterior borders; punctations few, fine. *Capitulum* (mutilated in the type) with base roughly equilateral-triangular, dorsal ridge slightly concave; cornua but slightly protruding, arising from lateral ridges; porose areas large, near posterior border, of irregular shape, depressed, bounded laterally by ridges, the interval less than their width with central depression flanked by ridges; (*Ventral aspect*) auriculae long, recurved, protruding outwardly, posterior portion of base quadrangular; hypostome? *Venter*: vulva facing third intercoxal space; anal grooves horse-shoe shaped, nearly joining behind; anus near posterior border; spiracle a short flattened oval, transverse, macula nearly central. *Legs*: coxa I with internal spur and postero-external protrusion, posterior margin trenchant; coxae II–III trenchant, unarmed; coxa IV slightly trenchant, with short postero-external spur; tarsi tapering

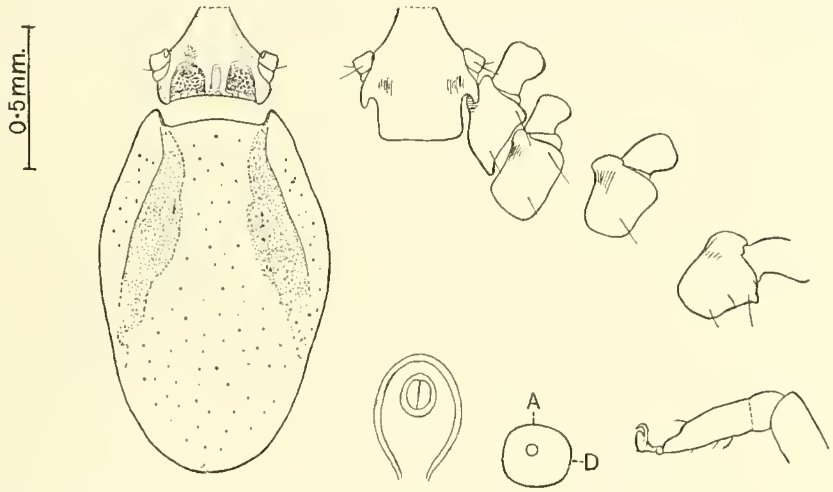

Fig. 4. *Ixodes nairobiensis* n. sp. ♀. Scutum, capitulum in dorsal and ventral aspects, coxae with trochanters, anus with anal grooves, spiracle and tarsus 4 (G.H.F.N. del.).

with a slight slope near the tips, the distal pseudo-article of tarsus 4 thrice as long as the basal; pads nearly as long as the claws.

Described from a single ♀ found on a *dog*, at the Veterinary Pathological Laboratory, Nairobi, **British East Africa,** 12. III. 1912, by Mr H. Branwhite and received from the Imperial Bureau of Entomology, London (No. 507) to whom the type belongs.

The species is allied to *I. lunatus* Neumann 1907, from Madagascar (see *Ticks*, Part II. pp. 226–227, figs. 222–223 ♀), but differs chiefly in having coxa I not bifid, coxae II–III unarmed, scutum longer and with distinct lateral ridges, basis capituli shorter and porose areas large.

Ixodes ricinus var. **gibbosus** n. var.

Fig. 5.

Resembles typical *I. ricinus* in all particulars but the following: *All the tarsi are humped distally in both sexes*; the ♂ scutum is larger and the ♀ scutum is somewhat smaller than in the type.

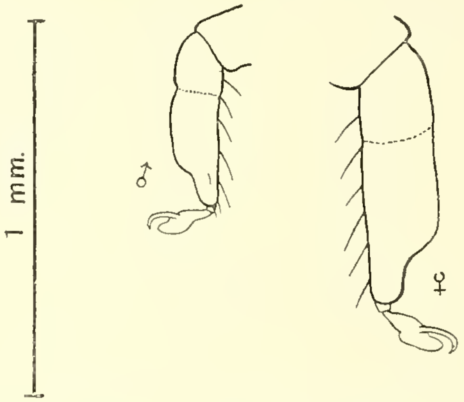

Fig. 5. *Ixodes ricinus* var. *gibbosus* n. var. (N. 2553) ♂ and ♀ tarsi of the fourth leg (G.H.F N. del.).

The scutums of 4 ♂ and 3 ♀ measure as follows in mm.:

♂	♀
2·03 × 1·0	1·17 × 1·23
2·05 × 1·08	1·18 × 1·13
2·10 × 1·07	1·26 × 1·18
2·10 × 1·07	

Described from (N. 2553) 5 ♂ 6 ♀ found by Mr W. H. J. van Heemstra on *Capra hircus*, Smyrna, **Asiatic Turkey,** XI. 1913, in company with *Hyalomma aegyptium* and *Haemaphysalis cinnabarina* var. *punctata*. Types in Cambridge.

Ixodes dentatus var. **spinipalpis** Hadwen and Nuttall 1915, n. var.

Figs. 6–8.

In 1911 Dr S. Hadwen sent me specimens named as above, accompanied by a short description and sketchy figures. Owing to difficulties in deciding about the determination the description of the variety has not hitherto been published.

The specimens appeared to be more or less closely related to *Ixodes fuscipes* Koch 1844, *I. dentatus* Marx 1899 and *I. boliviensis* Neumann 1904.

The ♀ differs as follows from a specimen from Panama, determined as *I. fuscipes* by Neumann (see *Ticks*, Part II. p. 169, Fig. 164), with which Mr Stanley Hirst of the British Museum kindly compared it in 1911. In *I. fuscipes* the scutum is broader and more angular, the cervical grooves are almost obsolete, coxa I bears a much longer internal spur and a less distinct external spur; the auriculae are broader and blunter (palps and hypostome absent in the type at the Museum). These differences are also shown in a second specimen drawn by me (*Ticks*, Part II. Fig. 163, from Neumann's collection[1]) in which the hypostome appears more pointed and the dentition 2|2; the spiracle distinctly larger, the tarsi more abruptly tapering, the pads as long as the claws. The descriptions we gave of the nymph and larva of *fuscipes* also differ from those of the new variety. We may therefore exclude *fuscipes* although the variety is closely related thereto.

The ♀ was next sent to Washington where Mr Nathan Banks kindly compared it with the type of *I. dentatus*, a mutilated specimen without palps, at the National Museum. From Banks' report thereon, kindly communicated by Dr L. O. Howard, our specimen differs from the type in having the scutum much longer and more evenly punctate; cornua a little more prominent; auriculae a little slenderer and perhaps pointing more downwards; coxa I with shorter and thicker internal spine; spiracle more elliptical. Mr Banks therefore considered it warranted for us to describe our specimen as a new variety or sub-species of *I. dentatus*, adding that quite possibly the discovery of the ♂ may ultimately show it to be a new species. Mr Banks adds that "the figure of *I. dentatus* rostrum in Neumann (reproduced by us in *Ticks*, Part II. Fig. 153) probably was not taken from the specimen now in Washington; in Marx MSS drawings there is a figure of the rostrum labeled *dentatus*;

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[1] Originally described as *I. spinosus* Neumann, the type was subsequently referred to *I. fuscipes* by Neumann after he had examined Koch's type. Specimen also from Brazil.

this is reproduced with other Marx figures in (Banks') *Ixodoidea of the United States*, Pl. IX, fig. 7; the teeth are longer than he shows but hardly as acute as Banks' figure on Pl. IV, fig. 6. Marx's figure of the shield, Pl. IX, fig. 3, is not broad enough behind." In Marx's figure reproduced by us in *Ticks*, the basis capituli appears short, the auriculae short and blunt, the hypostome 5|5; figure 154 of the coxae (also from Marx) show coxa I with a long slender spine.

The ♀ and ○ of our specimens also resemble corresponding stages of *I. boliviensis* Neumann, as will be seen by reference to *Ticks*, Part II. Figs. 161, 162, but the latter differ in showing no ventral spine upon the first palpal article; coxa I in the ♀ bears a long spur; the ○ has small almost obsolete cornua, small auriculae and hypostome with dentition 2|2, etc.

All of these forms appear to me to be so closely related that they may with time be found to represent but varieties of one species, *I. fuscipes*. Their geographical distribution also suggests this possibility. *I. fuscipes* occurs in Brazil (on *Dasyprocta agouti*) and Panama (on *Felis pardalis*); *I. boliviensis* occurs in Bolivia (on *Icticyon venaticus*); whilst *I. dentatus* occurs in the United States (on rabbit). The variety here described occurs in Western Canada (on *Lepus americanus* and *Sciurus hudsonius*).

Female (Fig. 6): Hard parts blackish brown, these and the body bearing long fine scattered hairs. (*Dorsal aspect*) *Scutum*: 1·4 × 1·02 mm., oval, with pointed scapulae, cervical grooves distinct, not attaining the posterior border, rounded lateral ridges, fine punctations uniformly distributed in the median field. *Capitulum* with base subtriangular, slight rounded cornua, porose areas piriform with interval equal to their length. Palps long, somewhat pointed distally, broadest at the distal end of article 2 which is longer than 3, a slight dorsal concavity; (*Ventral aspect*) *palpal article* 1 *with ventrally protruding spine*, auriculae large, curving inward and protruding ventrally (see figure); hypostome rounded distally, 3|3, about 10 teeth per outer file. *Venter* (semi-gorged specimen) with vulva between coxae III; anal grooves short, parallel, slightly ogival in front; spiracle ovoid. *Legs*: Coxa I with long pointed internal spine, a short external spur on all coxae, decreasing in size from coxa I to IV; tarsus 4 tapering obliquely, pad shorter than the claws.

Nymph (Fig. 7): Resembling the ♀. *Scutum* relatively shorter, 0·62 × 0·55 mm. *Capitulum* with cornua more marked and arising from lateral ridges; auriculae smaller; hypostome 3|3 followed by 2|2

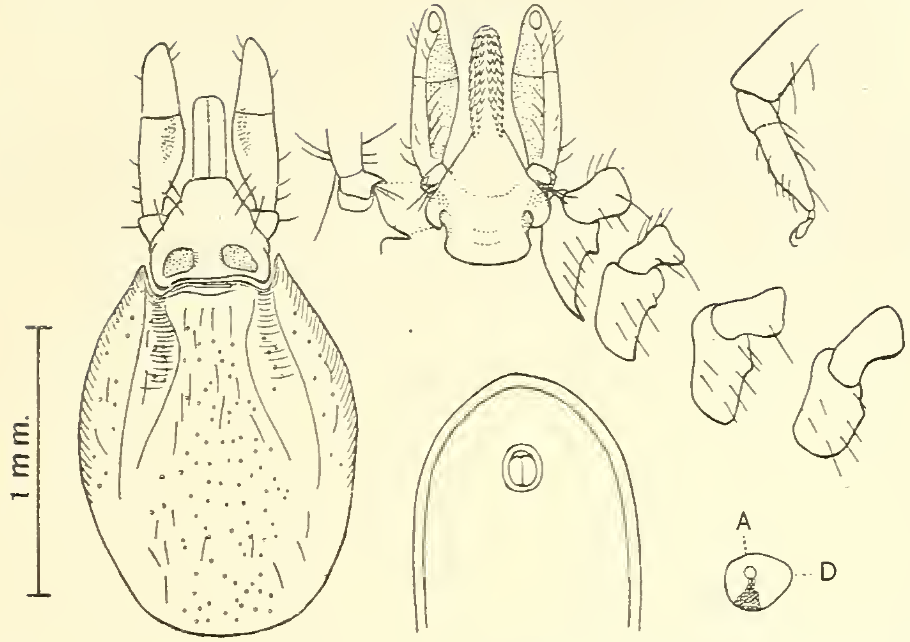

Fig. 6. *Ixodes dentatus* var. *spinipalpis* n. var. ♀ (N. 3180). Scutum, capitulum in dorsal, partly in lateral, and ventral aspects. Anus with anal grooves, coxae with trochanters spiracle and tarsus 4 (G.H.F.N. del.).

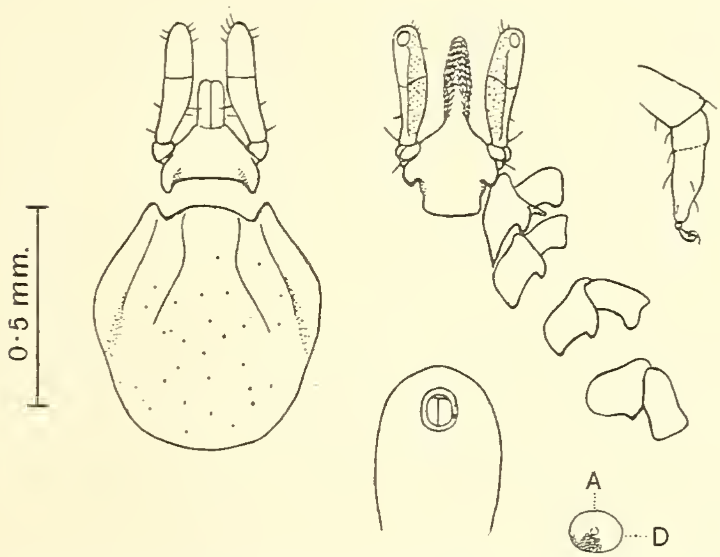

Fig. 7. *Ixodes dentatus* var. *spinipalpis* n. var., nymph (N. 3181) Scutum, capitulum in dorsal and ventral aspects, anus with anal grooves, spiracle and tarsus 4 (G.H.F.N. del.).

with 9 teeth per outer file; palpal article 1 with small ventral protrusion. *Legs* as in the ♀ but tarsi shorter.

Larva (Fig. 8): Somewhat resembling the ○. *Scutum* as broad as long (0·3–0·32 × 0·33 mm.), without lateral ridges, but slightly emarginate. *Capitulum* base very short, antero-lateral borders widely diverging, sharp postero-lateral angles with faint indication of cornua; slight auriculae; hypostome 3|3 with about 7 teeth per outer file; palpal article 1 with ventral angle. *Legs* recalling those of the ○ but coxa III unarmed.

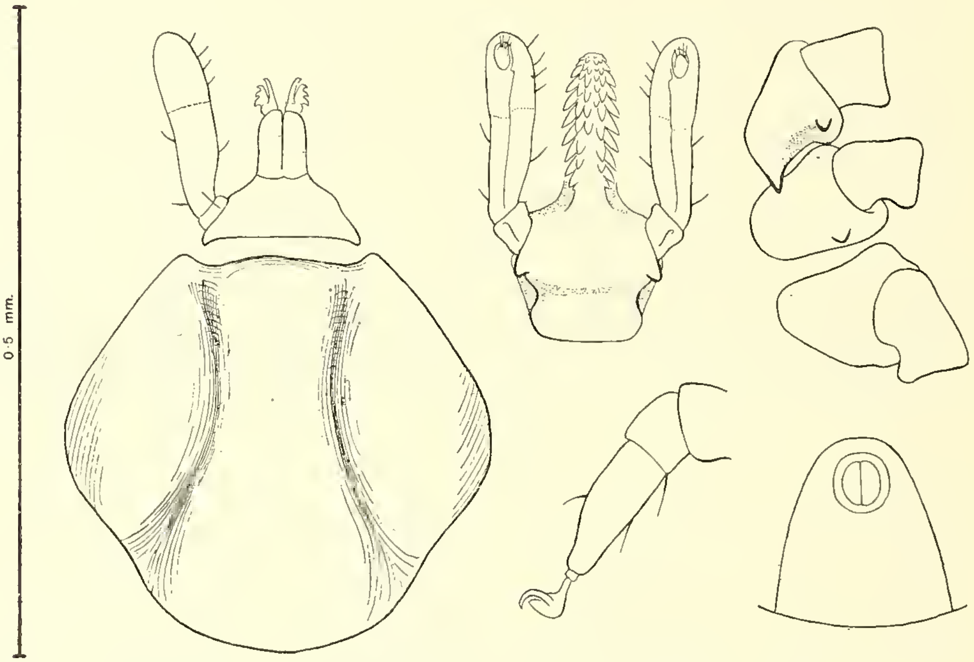

Fig. 8. *Ixodes dentatus* var. *spinipalpis* n. var., larva (N. 3181). Scutum, capitulum in dorsal and ventral aspects, coxae with trochanters, anus with anal grooves tarsus 3 (G.H.F.N. del.).

My description is based on (N. 3180) 1 ♀ found on *Lepus americanus*, 1. IX. 1910, (N. 3181) 3 ○ found on *L. americanus*, *Sciurus hudsonius douglasii* and upon a *child* respectively, besides 4 larvae (17 were originally collected) from *Lepus americanus*, 5. III. 1910, all taken at Mount Lehman, **British Columbia**, Canada, by Dr S. Hadwen.

Types in Cambridge.

2. DESCRIPTION OF HITHERTO UNKNOWN STAGES OF ESTABLISHED SPECIES.

Ixodes japonensis Neumann 1904.

Fig. 9.

Lit. and Icon.: Neumann, 1904, pp. 458–459 (♀ described but not figured). Nuttall and Warburton in *Ticks*, Part II. (1911), pp. 208–209, Figs. 200–201 (♀ redescribed and figured from the type).

The type of this species, a single ♀ (in the Paris Museum), was collected in the vicinity of Tokio, Japan, by J. Harmand in 1901. The following description and illustration relate to the hitherto unknown ♂ of this species; we add a note on the measurements of several newly acquired ♀s.

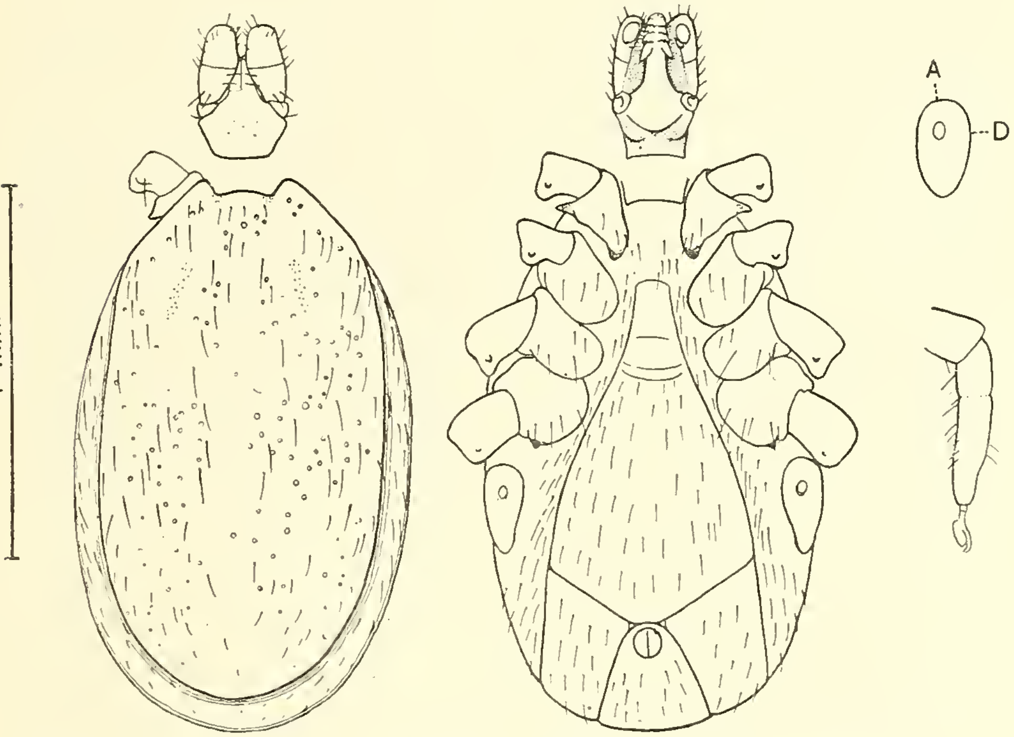

Fig. 9. *Ixodes japonensis* Nn. 1904 ♂ (N. 2948). Dorsum, venter, spiracle and tarsus 4 (G.H.F.N. del.).

Male (Fig. 9): Body 1·5 × 0·9, 1·75 × 1·1 or 1·8 × 1·3 mm., dark brown, with narrow marginal fold measuring 0·1 mm. in width posteriorly where it is widest; marginal fold with long white hairs; coxae I, visible dorsally, with a dorso-lateral spur-like process of which anon. (*Dorsal* *aspect*) *Scutum* oval, slightly flattened at the scapular margins, cervical grooves obsolete, glossy, coarse and medium-sized punctations irregularly distributed, long fine hairs. *Capitulum* base pentagonal, as broad as long, dorsal ridge straight, forming obtuse angles with the postero-lateral margins which diverge forwardly, with a few fine punctations; palps with article 1 small, articles 2–3 of equal length, distinctly articulated, when taken together over twice as long as broad; (*Ventral aspect*) article 1 with ventral protruding flange (also present in ♀); base with ventral ridge somewhat pointed, trenchant, and two more or less distinct rugose protrusions laterally; hypostome (of the *I. ricinus* type) with a single large basal tooth on each side and fine denticles distally in 4–5 transverse rows. *Venter*: Sexual orifice between coxae III; median plate broad, its postero-lateral angles far back, adanal plates short, anal grooves widely diverging behind (as in the ♀), all the plates, especially the epimeral, bear long hairs; spiracle ovoid, the blunt end directed forward. *Legs*: Coxa I with short internal spur continuous with the trenchant posterior border which runs on to an external ridge which ends abruptly giving it a spur-like look dorsally; coxae II–IV trenchant, coxa IV with a short broad-based external spur; legs hairy throughout; trochanters 1–3 with slight protuberance or small but distinct spurs; tarsi tapering gradually, the distal pseudo-article over twice as long as the basal; pads as long as the claws.

Female: Our description of the ♀ in *Ticks*, Part II. p. 208, needs no modification excepting on the subject of variability observed in 10 ♀s which have since become available. The *scutum* of the type measures 1·1 × 1·1 mm., that of the 10 newly acquired ♀s as follows in mm.:

0·9 × 0·94	1·04 × 1·05
0·97 × 0·98	1·05 × 1·05
0·97 × 1·0	1·07 × 1·04
0·97 × 1·0	1·10 × 1·04
1·02 × 1·03	1·13 × 1·05

Described from 3 lots (N. 2947–8–9) comprising 1 ♂ 1 ♀ from the collector's person, and 5 ♀ from a cow, taken in forests on the Ká-gur-pu Mountains (11,000 feet elevation), VI. 1913, and 1 ♂ 4 ♀ from the collector's person, taken at Dokerla (13,000 feet elevation), 1914; these localities are situated in the N.W. corner of Yünnan on the **borders of China and Tibet;** and (N. 3019*a*) 1 ♂, the largest, from the collector's person, taken in the jungle, Hpimaw District, **Upper Burma** (elevation 6000–8000 feet), 1914, together with *Ixodes acutitarsus* (Karsch, 1880)

♀ and *Rhipicephalus haemaphysaloides* (Supino, 1897) ♀; I am much indebted to my friend Mr F. K. Ward, B.A. (Christ's College, Cambridge), who collected these specimens for me on his travels and under great difficulties. We have also determined (Berlin 176) 1 ♀ taken at Genjiyama, Koshü, **Japan,** 5400–7000 ft., 11–12. VIII. 1905, by H. Sauter.

Type of the ♂ (N. 2948) in Cambridge.

Ixodes nuttalli Lahille 1913.

Figs. 10–13.

Lit. and Icon.: Lahille, F. (1913), *Bol. d. Ministero de Agricultura*, Buenos Aires, reprint 14 pp., 6 line figures and 3 half tone figures (Láminas 1–3). (The author also deals with *I. loricatus* Neumann, 1899, and refers to other species. Lamina 3 and figs. 4–6 represent *I. nuttalli.*)

Lahille's figures, obviously drawn from a balsam-mounted specimen, illustrate the male, its capitulum in ventral aspect, the spiracle and coxae with trochanters, highly magnified. The author gives elaborate measurements of which I only cite those of the body: 3·63 × 1·98 mm. He notes the resemblance to *I. angustus* Neumann 1899, and lays stress on the differences present in *I. nuttalli*: the very pronounced pseudoscutum, the form of the ventral plates, the peculiar coxal armature, all of which make it a distinct species.

As Lahille only describes the ♂, a single specimen at that, and I am able to describe all stages (♂ ♀ ○ ∠) from specimens received from Peru and found on a related species of host, I take occasion to redescribe the ♂ and figure it afresh in view of certain omissions in Lahille's description which is, however, sufficiently clear, especially with the aid of his figures, to render certain the determination of the species.

I find that the resemblance to *I. angustus*[1] holds for all stages, the nymph and larva of *I. nuttalli* being equally peculiar in respect to the structure of the capitulum. All stages show specific differences when compared.

Male (Fig. 10): (*Dorsal aspect*) Body long oval, 3·9 × 2·3 mm., widest in front of the mid-length at coxae IV, with sides narrowing slightly posteriorly to the spiracles; colour a dark chestnut brown; a broad protruding marginal fold in which the scutum appears sunk and overlapped. *Scutum*: 3·65 × 1·7 mm., with *extraordinarily developed pseudo-scutum*, bearing sharply defined protruding outer ridges convex externally; cervical grooves diverging and attaining the posterior margin of the pseudo-scutum where the median field protrudes: the pseudo-scutum somewhat rugose with moderate uniform punctations chiefly in the median field; the rest of the scutum smooth, convex, with a few fine punctations and hairs. *Capitulum*: small, 0·52 mm. long dorsally, base coarsely punctate, with short straight dorsal ridge continuous with the sides which diverge forwardly. Palps short and bulbous, article 1 small and inconspicuous, articles 2 and 3 clearly defined, 3 somewhat shorter than 2, both with many fine hairs; (*Ventral aspect*) base with slightly concave ventral ridge, sides diverging, almost straight; hypostome nearly as long as the palps, with inconspicuous teeth, 3|3, 5–6 teeth per outer file, emarginate distally. *Venter*: sexual orifice facing the second intercoxal spaces; pregenital plate small, broader than long; median plate much longer than broad, hexagonal; adanal, epimeral and anal plates very long; all plates finely punctate; spiracles ovoid, the long axis and blunter end pointing forward. *Legs*: Coxa I with short internal spur, and *two postero-external spurs* one

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[1] I take occasion here to correct an error in the description given of the nymph of *I. angustus* in our work *Ticks*, Part II. p. 197, Fig. 189, wherein the first palpal articles, protruding outward and backward ventrally, are wrongly described and figured as auriculae; the figure should be corrected in the light of the one herein given (Fig. 12) of *I. nuttalli*, the articulation in *I. angustus* being marked by a line running from the base of the hypostome outward and backward to the base of the so-called auricula on each side.

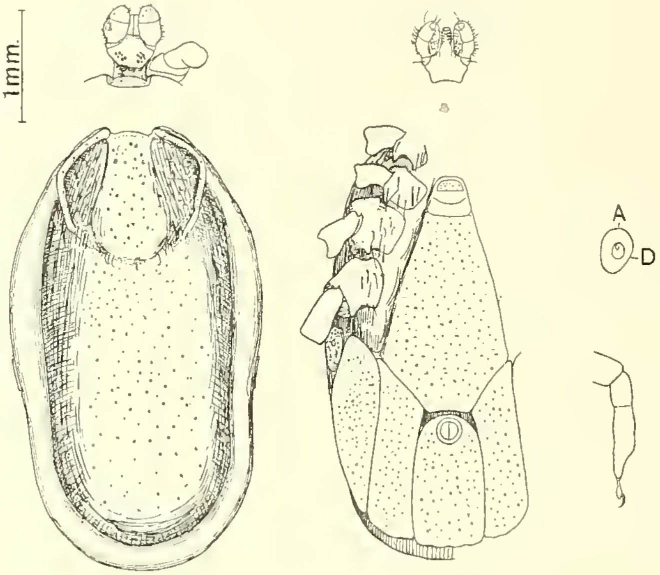

Fig. 10. *Ixodes nuttalli* Lahille 1913, ♂ (N. 2517). Dorsum, venter, capitulum in dorsal and ventral aspects, spiracle and tarsus 4 (G.H.F.N. del.).

dorsal and one ventral[1]; coxae II–III, each with two similar short and postero-external spurs; coxa IV with short postero-internal spur and postero-external tuberosity; trochanters unarmed; tarsus 4 tapering, distal pseudo-article about twice as long as the basal; pads small.

Female (Fig. 11): Hard parts dark chestnut brown. (*Dorsal aspect*) Body, when unfed, long and narrow, 3·7 × 2·0 mm., with scutum covering about half the length; marginal fold broad, prominent, complete, hairy; some scattered hairs on the abdomen. *Scutum* long oval, 1·9 × 1·3 mm., with scapular angles not pointed, emargination normal, lateral ridges prominent, and, as do the cervical grooves, extending far back to the postero-lateral borders; cervical grooves distinct, converging, then diverging slightly behind; the whole scutum somewhat rugose, especially in the lateral fields; posteriorly somewhat pointed; a few moderate punctations and fine hairs. *Capitulum* with base about as long as broad, roughly triangular, dorsal ridge sharp and sinuous, slight cornua; porose areas near the ridge, depressed, subtriangular, pointed forward, the interval narrow and prominent. Palps with

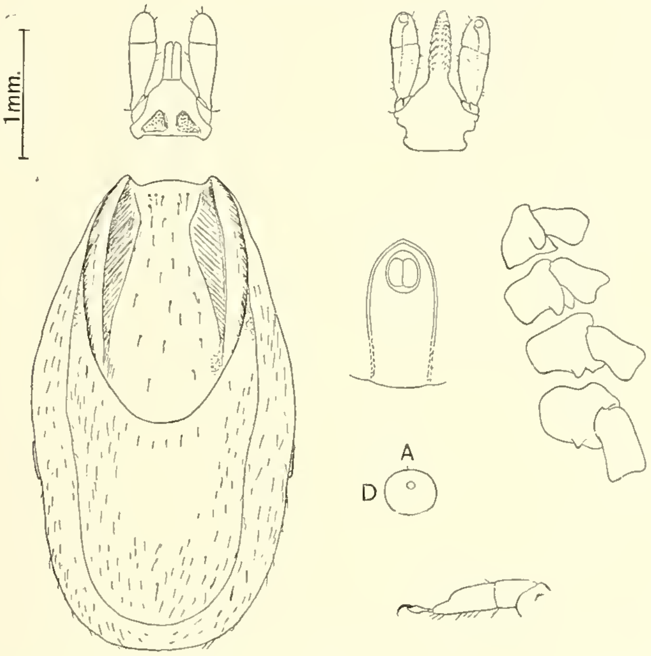

Fig. 11. *Ixodes nuttalli* Lahille 1913, ♀ (N. 2517). Dorsum, capitulum in dorsal and ventral aspects, anus with anal grooves, coxae with trochanters, spiracle and tarsus 4 (G.H.F.N. del.).

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[1] Recalling *Ixodes caledonicus* Nuttall 1910 (*Parasitology*, IV. 177–179, Fig. 1).

article 1 small, with slight internal angle; articles 2–3 club-shaped, the articulation distinct; article 2 about twice as long as 3; (*Ventral aspect*) palpal article 1 with protruding ventral angle; hypostome fairly pointed, with sharp teeth, 3|3, about 10 distinct teeth per outer file, fine denticles in front, with a short median unarmed ridge; basis capituli constricted rather far back; auriculae slight and rounded, basal margin straight. *Venter*: vulva between coxae III; anal grooves slightly ogival in front, converging slightly behind and extending to the posterior border; spiracle subcircular, with large eccentric macula.

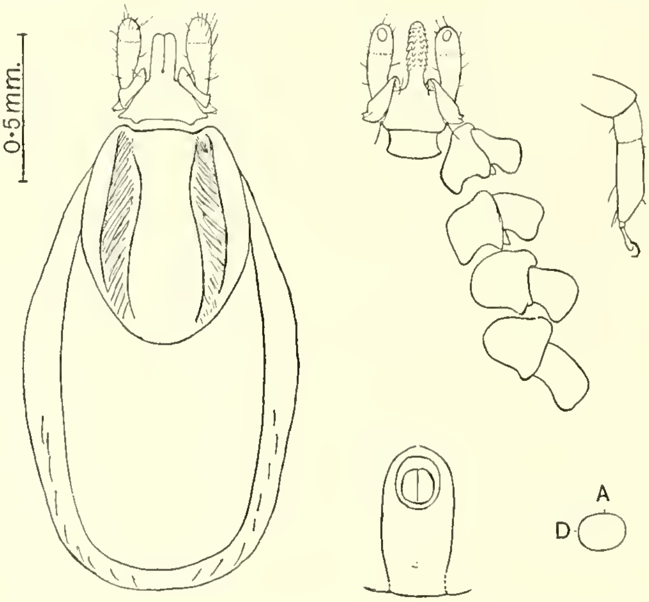

Fig. 12. *Ixodes nuttalli* Lahille 1913, nymph (N. 2514). Dorsum, capitulum in ventral aspect with coxae and trochanters, anus with anal grooves, spiracles and tarsus 4 (G.H.F.N. del.).

Legs: As in the ♂ but with postero-internal border of coxa IV rounded.

Nymph (Fig. 12): Recalling the ♀ in body-form and colour. Body 1·5 × 0·9 mm. (*Dorsal aspect*) *Scutum* 0·74 × 0·56 mm., resembles that of the ♀ but with more rounded scapular angles. *Capitulum* markedly different from that of the ♀, with lateral spines protruding outward outside the short rounded cornua. Palps far apart, with article 1 projecting forward as a pointed process hollowed internally alongside the shafts of the chelicerae; articles 2–3 club-shaped, the articulation indistinct; (*Ventral aspect*) article 1 running backward and outward in a bidentate process which could be mistaken for an auricula; from the underside of each article 1 there arises a single long hair; hypostome club-shaped, 2|2, about 7 distinct teeth per outer file; basis capituli narrowing and constricted posteriorly, with rounded ventral ridge terminating laterally in rounded protrusions. *Venter*: Anal grooves distinct, as in the ♀; spiracle small, oval. *Legs* closely resembling those of the ♀.

Larva (Fig. 13): Body broad when unfed. Resembles the nymph in certain respects. (*Dorsal aspect*) *Scutum*: Broader than long, 0·37 × 0·43 mm., with distinct cervical grooves diverging slightly and fading to the posterior border. *Capitulum* with short base, undulating dorsal ridge, slight cornua and distinct lateral spines. Palps with articles 2–3 short, club-shaped, of about equal length, article 1 as in the nymph when viewed dorsally but (in *Ventral aspect*) merely rounded posteriorly; hypostome and basis capituli as in the nymph. *Venter*: Anal grooves slightly divergent, attaining the posterior border. *Legs*: Coxa I with short postero-internal spur and *one* slight external spur, coxa II with slight postero-internal protuberance, coxa III unarmed; tarsi tapering gradually.

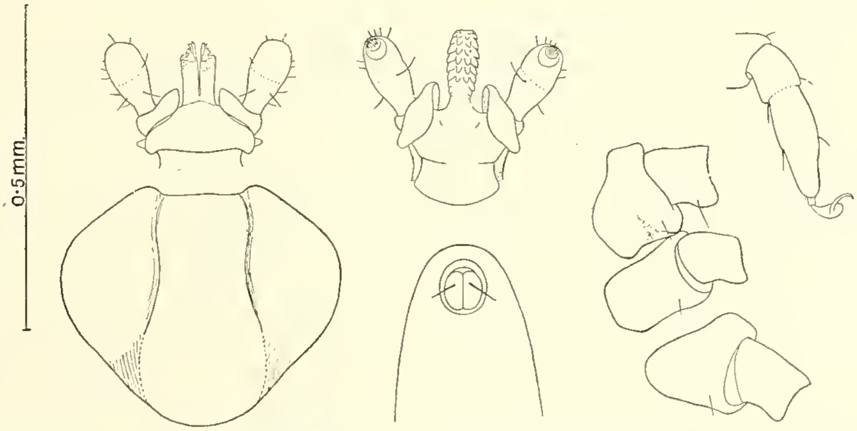

Fig. 13. *Ixodes nuttalli* Lahille 1913, larva (N. 2517). Scutum, capitulum in dorsal and ventral aspects, anus with anal grooves, coxae with trochanters, tarsus 3 (G.H.F.N. del.).

My description is based on (N. 2513–2515, 2517) 1 ♂, 2 ♀, 3 ○ and many larvae both fed and unfed, found on *Lagidium peruanum* Meyer at Ninahuanchi, **Peru,** elevation 800 feet, by Dr C. H. T. Townsend, Director de Estaciones Entomologicas, Dirección de Aguas y Agricultura, Lima, Peru. The adults and a nymph were taken on 1. II., two nymphs and many larvae on 11. III. and 1 larva on 14. V. 1913. Lahille's ♂

was found on "*Viscaccia viscaccia* (Mol.)" at San Rafael, Province of Mendoza, Argentina, in 1910.

The type ♂ is in Lahille's collection, the types of the other stages (N. 2513–2515, 2517) are in Cambridge.

Ixodes auritulus Neumann 1904.

Figs. 14–16.

The male of this species is still unknown. The female was described by Neumann and again by Nuttall and Warburton (*Ticks*, Part II. pp. 187–189, Figs. 180–181), whose description is illustrated by Neumann's original figures. These figures, except for that of the hypostome, are rather schematic.

Having received some good specimens from Peru and British Columbia I take occasion to give an accurate figure and some notes on the female coupled with the first published description, with figures, of the immature stages.

Female (Fig. 14): The new specimens (3 ♀s) agree with the description previously given in most particulars. The specimen herein figured was submitted to Neumann who agreed with our determination but thought that it might represent a variety owing to the scutum being slightly broader, the coxae slightly stouter and the legs somewhat longer than in the type. That the scutum varies in shape is clear to me, it may be either long or short as I have observed in other species of *Ixodes*. Two mutilated specimens from Tierra del Fuego, examined by us at the British Museum, and determined by Neumann, have long scutums with angular sides. The scutums of the three new specimens measure respectively 1·4 × 1·2 (♀ from Canada, N. 3178), 1·25 × 0·95 and 1·0 × 0·8 mm. (♀s from Peru, N. 2518, 2520). Variation is also shown in the dentition of the hypostome, that of the type is 6|6 followed by 4|4 rows of teeth; our Canadian specimen, here figured, shows dentition 5|5 followed by 4|4 and so does one of the specimens from Peru whilst the second Peruvian example shows dentition 3|3. We have observed similar variability in the dentition of the hypostome in *Haemaphysalis leachi*. In the new specimens the scutal punctations vary somewhat, the spiracles are short oval (rounded in the type), the porose areas of irregular form, the second and third palpal articles certainly fused. I consider that we are merely dealing with a species showing considerable individual variability in points of mere detail.

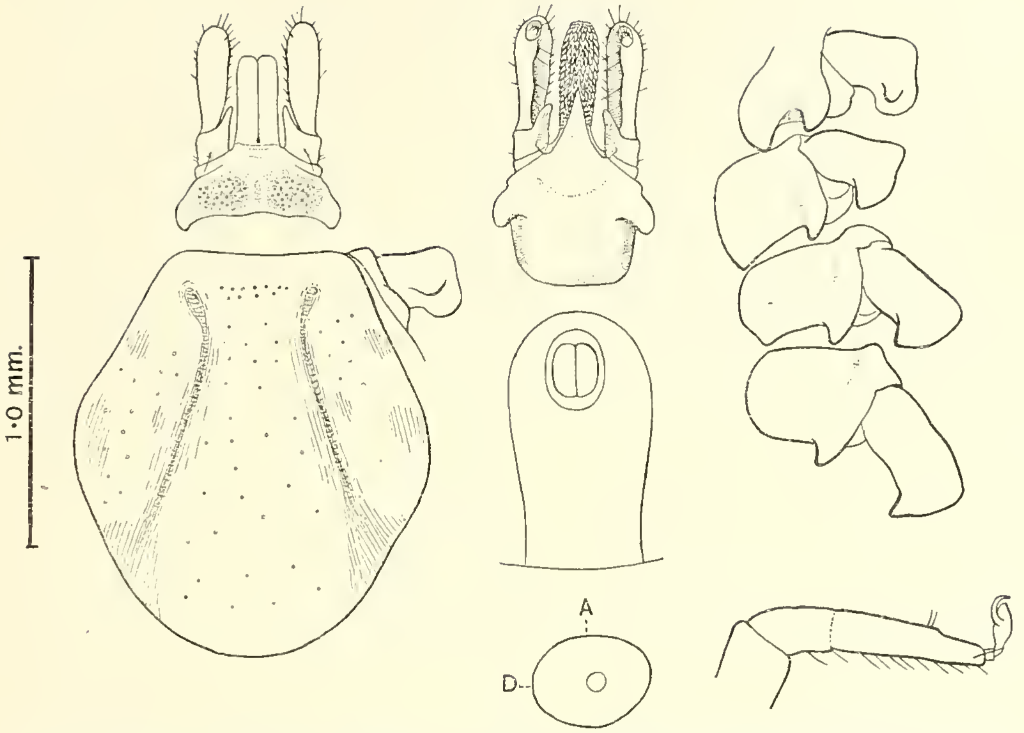

Fig. 14. *Ixodes auritulus* Neumann 1904, ♀ (N. 3178). Scutum with part of leg I, capitulum in dorsal and ventral aspects, anus with anal grooves, coxae with trochanters, spiracle and tarsus 4 (G.H.F.N. del.).

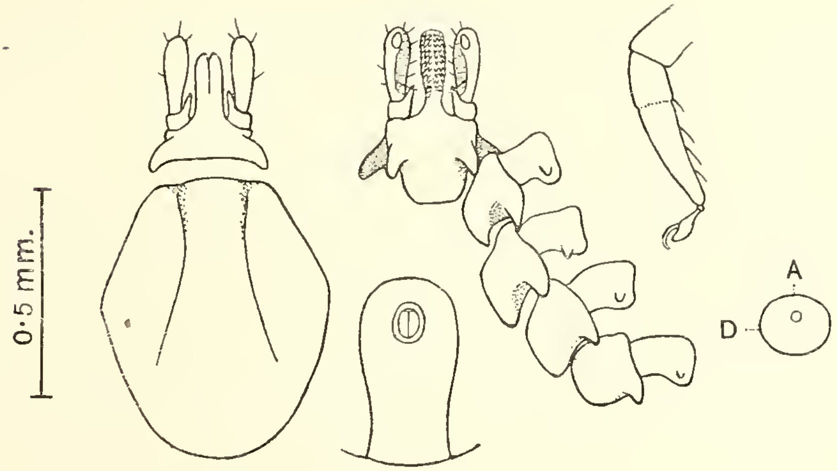

Fig. 15. *Ixodes auritulus* Neumann 1904, nymph (N. 3179). Scutum, capitulum in dorsal and ventral aspects, anus with anal grooves, coxae with trochanters, spiracle and tarsus 4 (G.H.F.N. del.).

Nymph (Fig. 15): Closely resembling the ♀. *Scutum* somewhat more elongate (the scutums of a Canadian specimen measured 0·7 × 0·56 mm., those of three Peruvian specimens measured 0·55 × 0·48, 0·53 × 0·4, 0·51 × 0·48). Hypostome 3|3 followed by 2|2, about 10 teeth per external file.

Larva (Fig. 16): Closely resembles the ○ but the scutum is short (0·35 × 0·36 mm.) and the hypostome 2|2 with 7 teeth per outer file.

Geographical Distribution and Hosts: The species is widely distributed. The type ♀s (4 specimens) were collected at Punta Arenas, **Straits of Magellan,** by Lebrun, from an undetermined bird; the 2 ♀s in the British Museum were found on *Trupialis militaris*, San Sebastian, **Tierra del Fuego,** x. 1906, by Crawshay. Our new specimens are (N. 2518) 1 ♀ from *thrush*, Oroya, **Peru,** 7. III. 1913, and (N. 2520) 1 ♀, 3 ○s from *pipit*, Junin, Peru, 19. III. 1913, both lots having been collected and presented by Mr C. H. T. Townsend. We have determined (Berlin 156) 1 ♀ from "Baumhuhn" (a bird described by collector as blueish with black neck), foot of Mt Turrialba, 1600 m. elevation, 25 kilometres E. of Cartago, **Costa Rica,** C. America. Dr S. Hadwen has kindly sent us from Canada: (N. 3178) 1 ♀ from *Haliaetus leucocephalus alascanus* (Bald Eagle), 17. VI. 1910, and 1 ○, 1 ∠ (10 larvae were comprised in the original lot) from *Cyanocitta stelleri carlottae* (Queen Charlotte Jay), 23. VI. 1910, taken at Masset,

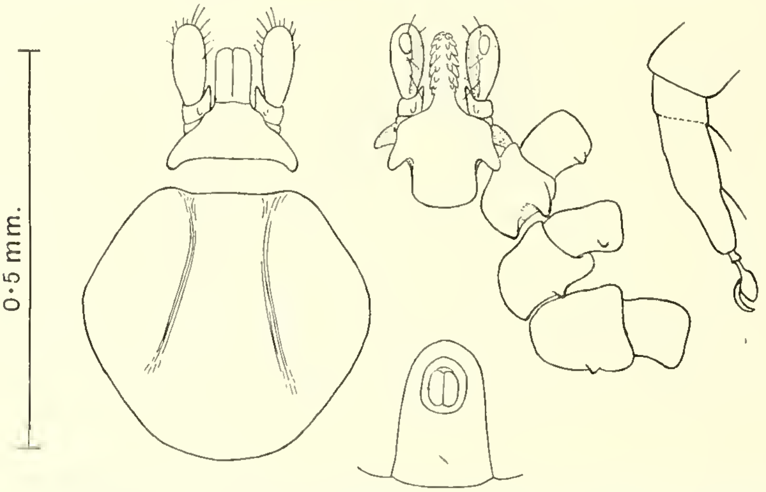

Fig. 16. *Ixodes auritulus* Neumann 1904, larva (N. 3179). Scutum, capitulum in dorsal and ventral aspects, anus with anal grooves, coxae with trochanters, tarsus 3 (G.H.F.N. del.).

Queen Charlotte Islands, British Columbia, by Mr E. M. Anderson, Assistant Curator of the Provincial Museum.

We have recently determined (P. 37) ♀ from head of king penguin, *Aptenodytes patagonica,* Lusitania Bay, Macquarie Island, 14. xii. 1912, and (P. 4 + 733) many ♀s and ○s from skua, *Megalestris antarctica,* **Macquarie Island,** H. Hamilton coll. (Australian Antarctic [Mawson] Expedition).

Of the species of *Ixodes* occurring in birds, only three (*I. brunneus, I. putus* and *I. signatus*) show an equally wide geographical distribution.

The type ♀s are in the Paris Museum and in the Neumann collection, Toulouse, they were originally described by Neumann in 1899 as *I. thoracicus*; the types (N. 3179) of the immature stages are in Cambridge.

3. Species now Recognized as Valid and Redescribed after Examination of the Types.

Ixodes granulatus Supino 1897.

Fig. 17.

Lit. and Icon.: Supino, 1897, p. 16, Pl. III, figs. 1–10 and 1897, p. 250, Pl. XII, figs. 5–6. Neumann, 1899, p. 164; 1902, p. 125. Nuttall and Warburton, 1911 in *Ticks,* Part ii. pp. 291–292, where it is given as a doubtful species, the author's and Neumann's description being insufficient.

Male: Unknown.

Female (Fig. 17): Hard parts light chestnut brown. (*Dorsal aspect*) *Scutum* with very pointed scapular angles, emargination moderate, as long as broad or longer (0·9 × 0·9 to 1·1 × 0·8 mm.), oval, broadest about mid-length; cervical grooves faint, closely converging near the emargination, then diverging without attaining the borders, lateral ridges bounding outwardly a depressed elongate area almost free from punctations which is limited internally by the cervical grooves, the ridges may or may not attain the postero-lateral borders; punctations numerous, coarse, uniformly distributed, chiefly in the median field; hairs absent. *Capitulum* (0·8 mm. long dorsally): Base long, somewhat triangular, dorsal ridge almost straight, cornua absent; porose areas large, shallow, pear-shaped or irregularly triangular, near the dorsal ridge, the interval about equal to their length; palps long, article 3 shorter than 2, both slightly hollowed dorso-internally, article 3 rather pointed distally, article 1 small and protruding; (*Ventral aspect*) hypostome moderately pointed, dentition 2|2 to 3|3, with about 10 sharp teeth per file and a median unarmed ridge; auriculae small, edged; posterior portion of base moderately broad, rounded behind. *Venter*: Vulva between coxae IV; anal grooves somewhat ogival, short, not attaining the posterior border; spiracles sub-circular, macula central. *Legs*: Coxa I with sharp internal and short external spur; coxae II–IV with external spurs progressively decreasing; tarsi tapering step-wise, pad as long as the claws.

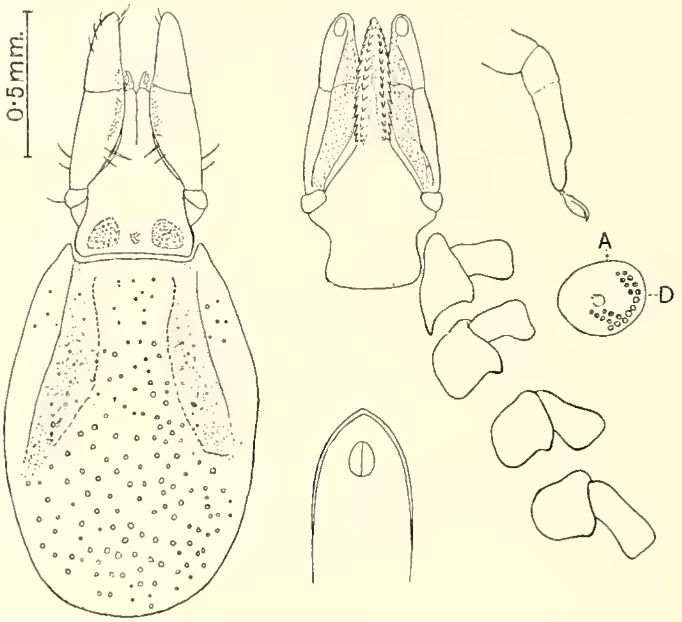

Fig. 17. *Ixodes granulatus* Supino 1897, ♀ (N. 2966 co-type). Scutum, capitulum in dorsal and ventral aspects, coxae with trochanters, anus with anal grooves, spiracle and tarsus 4 (G.H.F.N. del.).

My description is based on the examination of types and co-types collected in 1885–1889 by L. Fea and stated by Supino to have been collected from *Sciurus gordoni*, *S. rufigenis*, *S. striatus* and *Felis tigris* at Bhamo, Mooleyis, Tarawaddy and Terinzo in Upper and Lower **Burma.** I have recently determined 3 ♀s (Indian Mus. $\frac{2345}{17}$ = N. 3193) found on *Epimys rufescens*, Peshok, Darjeeling District, **India,** by R. S. Lister.

Types in the Genoa Museum (No. 37), co-types (N. 2966, 4 ♀) in Cambridge. A good species closely allied to *Ixodes angustus* Neumann 1899.

Ixodes anatis Chilton 1904.

Figs. 18–19.

Lit. and Icon.: Chilton, C., 1904, pp. 201–202, Pl. X, figs. 1–6.

The description of this species was not included in *Ticks*, Part II., the publication by Professor Chilton having unfortunately been overlooked. The tick was described by Chilton in 1904 from specimens found on *Anas superciliosa*, the grey duck, and received by him in May, 1903, from Mr W. W. Smith of Ashburton. The author's description and figures, whilst insufficient for identification, give certain precise data: *Ixodes* ♀, size, when replete, 10 × 5 mm.; palpal article 2 twice as long as 3, article 1 massive; hypostome with dentition 2|2, as long as the palps. Smaller specimens, measuring 3 × 1·5 mm., similar to the female, were thought by Chilton to be males. Mr Smith reported of their colour when alive: "Females dull-green, males brownish green." (It is clear that the supposed males were nymphs.)

Through the courtesy of Professor Chilton I received, in 1913, (1) a perfect ♀ co-type on loan from the Canterbury Museum for purposes of examination, (2) parts of a second ♀ (type from which his figures were drawn) mounted in balsam, and also, in 1912, the rest of this female together with (3) a nymph preserved in alcohol.

These specimens agree with 2 ♀s since received (1914) from Professor Chilton, one of which is herein figured by me. The scutum is mutilated in the type, but as also in the co-type, it is more bluntly rounded posteriorly than in my figure and the shallow cervical grooves attain or nearly attain the posterior borders; the porose areas are rounded instead of somewhat angular; the distal pseudo-article of tarsus 4 is somewhat longer. All of these differences are slight and merely individual and but for them my figure agrees with the appearance of the co-type and what can be made out from the remains of the type.

If the types of the purely nominal species *I. apteridis* Maskell 1897 (from *Apteryx mantelli*, inland from Mt Egmont, New Zealand; Maskell, p. 291) and *I. aptericola* Maskell 1897 (from *Apteryx australis*, Dusky Sound, New Zealand; Maskell, p. 292, Pl. XVII, figs. 7–8) should ever be found, it is reasonable to suppose that *I. anatis* Chilton and *I. aptericola* Maskell will fall into the synonymy of *I. apteridis* Maskell. Prof. Chilton informs me, however, that there is little hope of recovering the types of Maskell's species here referred to. (The last remark also holds for *I. maskelli* Kirk 1887, from the albatross, *Diomedea exulans*, New Zealand (Kirk p. 66) which remains undeterminable, the author's description being useless.)

Male: Unknown.

Female (Fig. 18): Hard parts amber yellow. (*Dorsal aspect*) *Scutum* very slightly emarginate, pentagonal, with lateral and posterior angles broadly rounded, antero-lateral margins straight or slightly curved outwardly, postero-lateral margins sinuous, not as long as broad 1·5 to 1·4 × 1·65 mm. (1·3 × 1·5 in the co-type), broadest at mid-length; cervical grooves marked by shallow divergent depressions sometimes attaining the posterior borders; few fine punctations interspersed with coarser ones. *Legs*: Coxa I visible dorsally, its

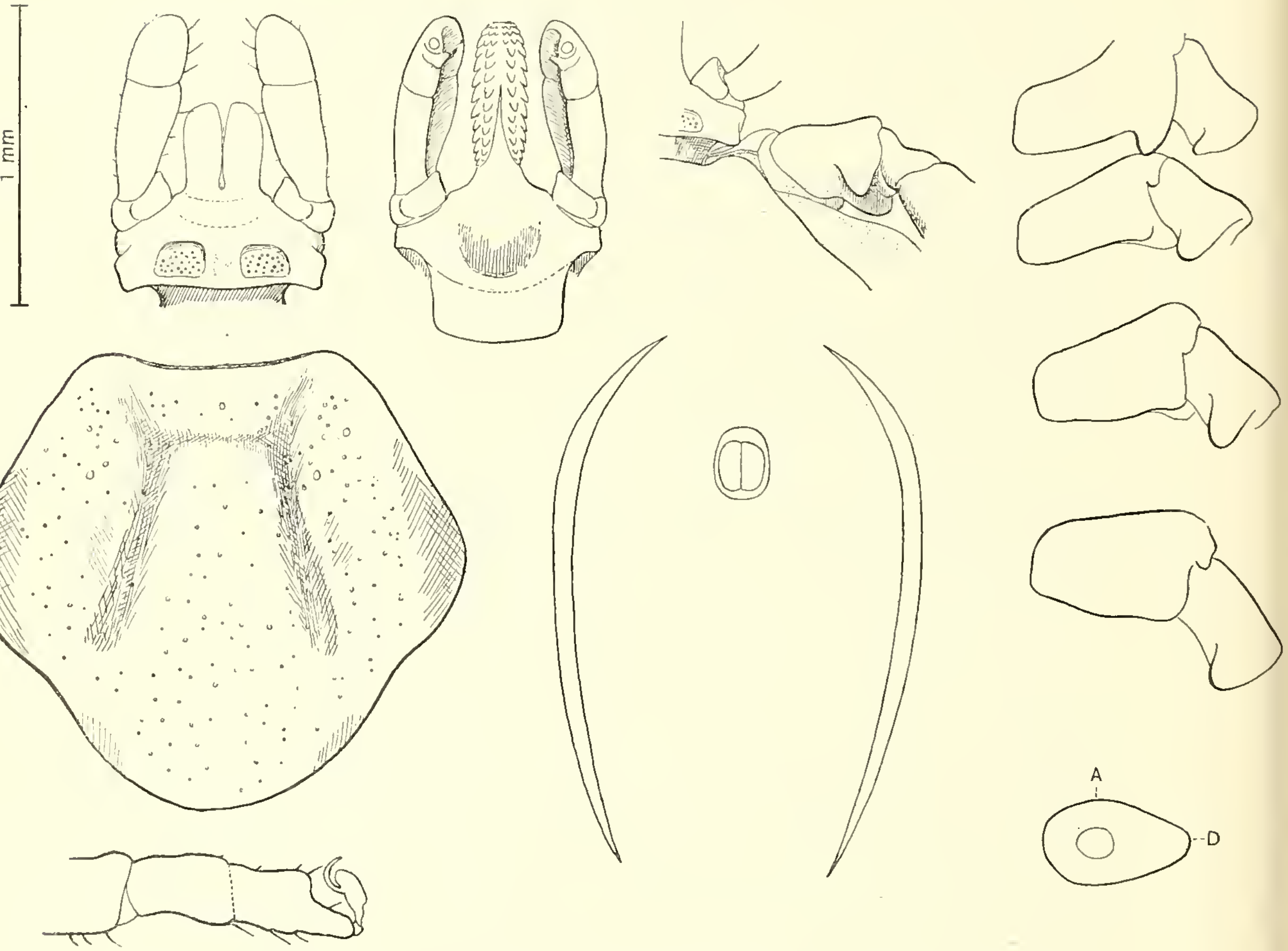

Fig. 18. *Ixodes anatis* Chilton 1904, ♀ (N. 2751). Scutum, capitulum in dorsal and ventral aspects, part of leg I seen dorsally, coxae and trochanters, spiracle, anus and anal grooves, tarsus 4 (G.H.F.N. del.).

trochanter with dorsal spur. *Capitulum*: Base short, broad, with slight rounded cornua continuous with the trenchant dorsal ridge; porose areas deep, somewhat angular or rounded, with interval slightly less than their length. Palps of medium length, with article 2 twice as long as 3, article 1 large and massive, projecting forward internally and with protruding angles both dorsally and ventrally; (*Ventral aspect*) hypostome with moderately pointed teeth, 2|2, except distally where they are 3|3, there being 12–14 teeth per outer file with a short median unarmed ridge; basis capituli constricted near palps, posteriorly almost quadrangular, somewhat hollowed in the middle. *Venter*: Vulva facing second intercoxal spaces; anal grooves not joining in front but forming two crescentic lines converging in front and behind the anus; spiracles long ovoid, with long axis transverse, the tapering end directed dorsally. *Legs* with all coxae trenchant, coxa I only bearing a stout postero-external spur with rounded tip; trochanters armed with similar spurs; tarsus 4 short, humped distally where it tapers abruptly; pad short. A fully gorged specimen measured 10 × 7 mm.

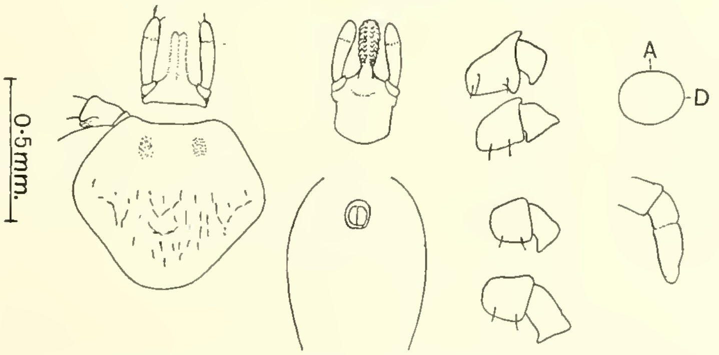

Fig. 19. *Ixodes anatis* Chilton 1904, nymph (co-type). Scutum with part of leg I, capitulum in dorsal and ventral aspects, anus with anal grooves, coxae with trochanters, spiracle, tarsus 4 (G.H.F.N. del.).

Nymph (Fig. 19): The nymph bears a general resemblance to the ♀. *Scutum* shaped as in the ♀, cervical grooves practically obsolete, the posterior half bears fine hairs. *Capitulum* base very short with antero-lateral borders forming an acute angle with the dorsal ridge which is almost straight; palps relatively more slender and with article 1 smaller than in the ♀; hypostome 2|2, with 10 distinct teeth per outer file. *Venter* as in the ♀ but the spiracle less elongate. *Legs* as in the ♀ but tarsi not humped distally where they taper.

Described by me from 2 ♀ and 1 ○ (types and co-type) found on *Anas superciliosa* in 1904 by Mr W. W. Smith of Ashburton, **New Zealand,** and from 2 ♀ from *Apteryx mantelli*, North Island, New Zealand, III. 1914, likewise collected by Mr Smith who reports that this tick infests young kiwis about the ears and top of the head, occurring about the base of the rudimentary wings in old birds; when alive the ticks appear dark blue with brilliant red legs. This description of the colour does not appear to accord with that previously given, no doubt the colour of the legs was overlooked in the first instance whilst the colour of the body will vary according to the state of repletion and the time which has elapsed since the tick sucked blood.

Ixodes eudyptidis Maskell 1885.

Lit. and Icon.: Maskell, W. M., 1885, pp. 19, 20, Pl. VIII, figs. 12–14. Other references follow in the text.

This tick is referred to in our work *Ticks*, Part II. p. 291, under doubtful species. Maskell described it so badly that it was impossible to determine the validity of the species; the author's statement that it was "evidently a true tick" appeared, however, to be justified. The scutum was described as hairless, glossy, and with many fine and shallow punctations. The types were found "in the gape of the penguin" at Dusky Sound, **New Zealand.** Judging from the author's bad figures we concluded that the tick might be *I. putus* (O. Pickard-Cambridge, 1876).

In *Ticks*, Part II. pp. 217–220, Figs. 213 (♀) and 214 (○) under the name of *I. neumanni*, Nuttall and Warburton redescribed specimens from Neumann's collection which had been collected in New Zealand by Suter, the host unrecorded. These specimens had been referred to *I. eudyptidis* Maskell by Neumann (1899, p. 128) who had not seen Maskell's types. As already stated, Maskell's description was useless and we concluded that Neumann merely guessed at the determination on the ground that the specimens collected by Suter likewise came from New Zealand. This justified our redescribing Neumann's purported *I. eudyptidis* as *I. neumanni* failing access being obtainable to Maskell's types. Neumann (1904, p. 451) himself degraded *I. praecoxalis* Nn. 1899, and *I. intermedius* Nn. 1899, to the rank of synonyms of "*I. eudyptidis* Maskell."

Through the kind help of Prof. Charles Chilton of Canterbury College, New Zealand, I have been able to examine a co-type ♀ of *I. eudyptidis*

Maskell, accompanied by a ○ which I have determined as belonging to the same species. Both specimens are deposited in Canterbury Museum.

Our description of *I. neumanni*, above referred to, applies to Maskell's co-type ♀ except that trochanter 4 shows a spur and that the spur on trochanter 1 is distinct. These spurs were omitted in our Fig. 213, which could, except for this detail, be taken for a portrait of the co-type. The latter is a partly gorged specimen whose scutum measures 1·4 × 1·05 mm. The accompanying ○ measures 0·6 × 0·6 mm.

I therefore re-instate Maskell's species name, synonyms of which are:

I. praecoxalis Neumann 1899, p. 121; 1902, p. 119; 1904, p. 451; 1911, p. 21.

I. intermedius Neumann 1899, p. 132; 1904, p. 451; 1911, p. 21.

I. eudyptidis eudyptidis (Maskell) Neumann, 1911, p. 21.

I. neumanni Nuttall and Warburton, 1911, pp. 217–220, Figs. 213, 214.

4. SPECIES REDESCRIBED FROM BETTER SPECIMENS THAN THE TYPES, ETC.

Ixodes tasmani Neumann 1899.

Fig. 20.

The description of this species (♀) given in *Ticks*, Part II. (pp. 244, 245, Figs. 239, 240), was based on that of Neumann (1899, pp. 144, 145, Fig. 20) with slight modifications made after I had examined the type in the Paris Museum. Neumann's figure, reprinted from the original block, and one I drew from the type served to illustrate our description. The type female I drew was an old pinned, very brittle and shrivelled specimen collected by Verreau in Tasmania in the year 1847.

Having recently had occasion to determine two well-preserved (♀) specimens from Australia, it appears advisable to redescribe the species from them, especially as our earlier description of the capitulum is misleading. Moreover, the hosts of this interesting and rare species have not as yet been recorded.

As the ♂ ○ and larva have hitherto been unknown, I venture to give a *provisional description* of their salient features as far as they can be made out from specimens mounted in balsam by T. H. Johnston. The slides, which were lent to me for examination by Mr L. Harrison, include 1 ♂ 5 ♀ 3 ○ and 1 ∠. It is hoped that good specimens will be available for adequate description and illustration in the future.

Male: *Scutum* 3 mm. long, deeply emarginate, tapering to a rounded point behind. *Capitulum* resembling that of the ♀ in structure but differing in shape (as is usual in males of this genus), being small, with long narrow base; very broad palps widening and rounded distally, article 1 resembling that of the ♀; hypostome 2|2, shaped as in the ♀. *Legs*: Coxae, and apparently the tarsi, as in the ♀.

Female (Fig. 20A): When unfed, the body measures 3 × 1·8 mm., it is ovoid, broadest on a level with coxae IV, the marginal fold almost complete. (Gorged specimens attain 10 × 7 mm.) Capitulum and scutum light chestnut brown, legs paler. (*Dorsal aspect*) *Scutum* about as long as broad, 1·4 × 1·54 mm., with moderate emargination, sides straight and divergent, lateral angles far back and rounded, posterior border slightly sinuous; cervical grooves distinct, straight, slightly divergent, not attaining the posterior borders, no lateral ridges, moderate punctations or confluent punctations uniformly distributed and giving a rugose appearance, no hairs. *Capitulum peculiar*, base very short, pentagonal, with antero-lateral margins long, cornua absent; porose areas depressed, of irregular form, their long axes oblique, the interval hollowed and exceeding their width (less than their width in the type). Palps far apart, with article 1 extraordinarily developed, protruding like a cuff about the shaft of the chelicera and closely articulated with the basis capituli, with a protruding external process situate ventrally but seen dorsally; articles 2–3 fused, club-shaped, narrow behind, broadly rounded in front; (*Ventral aspect*) basis capituli with sides parallel, palpal article 1 with protruding flange internally; hypostome broad distally 4|4, then 3|3, very narrow posteriorly, with numerous very fine teeth 3|3 basally. *Venter*: Vulva between coxae IV; anal grooves broadly rounded in front, curving towards each other behind and diverging where they approach each other and indent the posterior border; spiracle ovoid, small, with long axis transverse, macula eccentric. *Legs*: Coxae large, unarmed, flanged; trochanters unarmed; tarsi tapering stepwise, pad almost as long as the claws.

Nymph: *Scutum* short, as in the ♀. *Capitulum* recalling that of the ♀; hypostome 3|3 distally, mostly 2|2, narrowing posteriorly in the same characteristic manner as in the ♀, and also with teeth dwindling in size toward the base; palpal article 1, seen ventrally, projects well outward as a recurved pointed flange. *Legs:* coxae and tarsi as in the ♀.

Larva: Recalls the nymph: Scutum short. Hypostome rounded distally, 2|2, there being 7 strong teeth per outer file.

Described from (N. 2190) a ♀ found on *Trichosurus vulpecula*, **Queensland,** IV. 1913, by Dr T. L. Bancroft, also from a second ♀ found on *Dasyurus maculatus*, Zoological Gardens, Melbourne, **Victoria,** 11. VII. 1911, by Dr Stupeley and communicated by Dr Georgina Sweet (No. 325). This specimen differs but slightly from the foregoing in

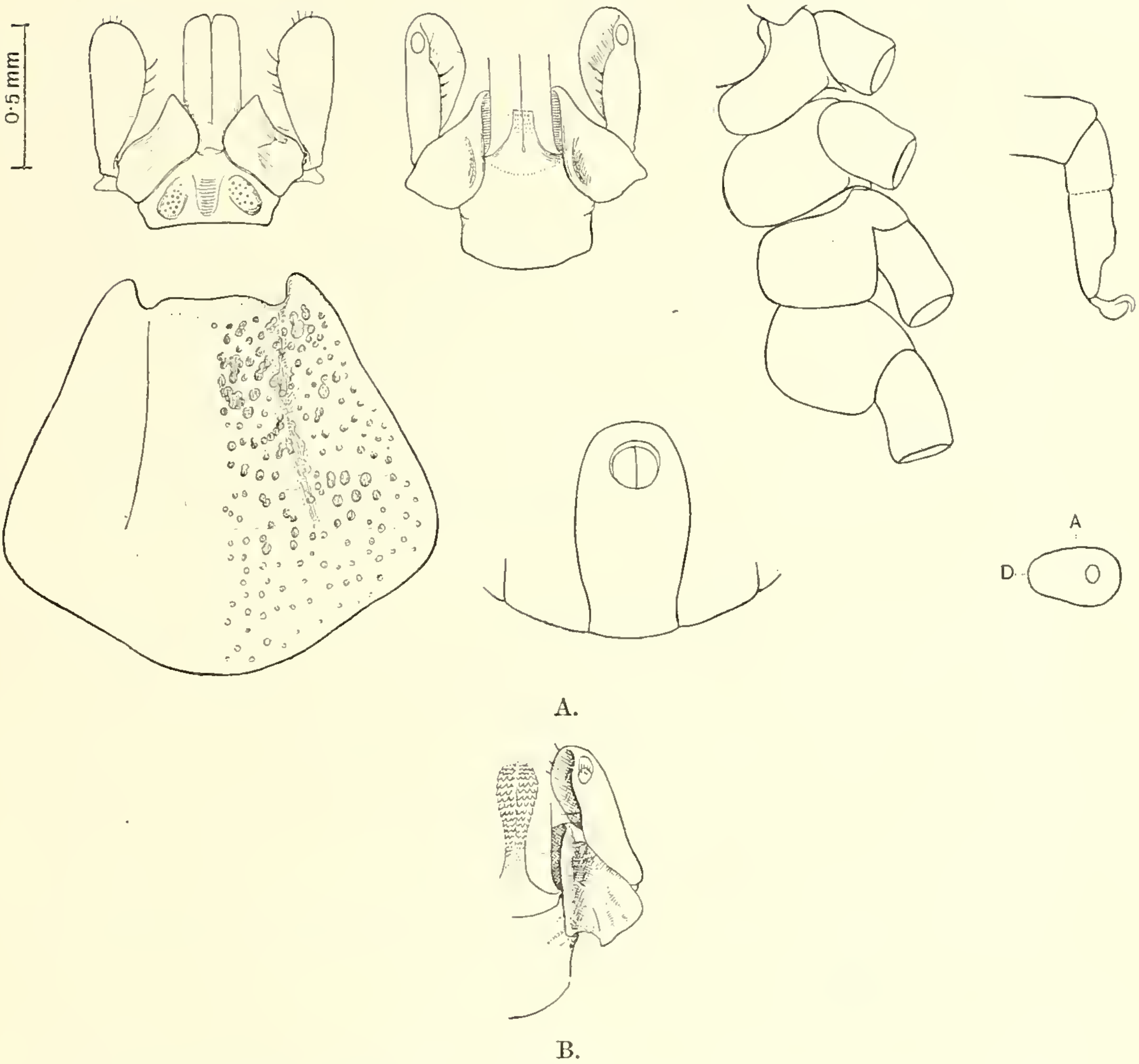

Fig. 20. *Ixodes tasmani* Neumann 1899, ♀.

A. (N. 2190) from Queensland, Australia. Capitulum in dorsal and ventral aspects, scutum, anus with anal grooves, coxae with trochanters, spiracle and tarsus 4.

B. Specimen (No. 325 Sweet Collection) from Victoria, Australia. Portion of capitulum in ventral aspect (G.H.F.N. del.).

that the ventral surface of palpal article 1 (see Fig. 20 B) is rugose and has its postero-internal angle curved inward and pointed; this is doubtless only an individual difference.

The description of the other stages is based on the following specimens from Victoria: (J. 1–3) 1 ♂ 3 ♀ from *Petauroides volans*; (J. 4–6) 1 ♀ 2 ○ 1 ∠ from *Trichosurus vulpecula*, Gippsland; (J. 15–16) ♀ ○ from *Phascolarctus cinereus*, Gippsland; all mounted unfortunately in balsam by T. H. Johnston.

5. Further Data regarding the Geographical Distribution and Hosts of *Ixodes*.

The following records relate to specimens determined by Mr Warburton and me since the publication of *Ticks*, Part II. in 1911. The names or letters and numbers in brackets relate to the catalogues of various collections; where such numbers are connected by the sign = the specimens have been divided between two collections:

	Denotes collection of
Ashworth	Dr J. H. Ashworth, Zoological Dept., University of Edinburgh.
Berlin	Zoologisches Museum, Berlin.
Cleland	Dr J. Burton Cleland, Bureau of Microbiology, Sydney, N.S. Wales.
E.	Imperial Bureau of Entomology, London.
H.	Mr. L. Harrison, University of Sydney, N.S. Wales.
Ind. Mus.	Indian Museum, Calcutta.
J.	Dr T. H. Johnston, University of Queensland, Brisbane.
Knuth	Prof. Knuth, Tierärztliche Hochschule, Berlin.
Liverpool	Liverpool School of Tropical Medicine.
Mitzmain	Mr M. B. Mitzmain, U.S. Public Health Dept., Washington, D.C.
Miyajima	Dr M. Miyajima, Imperial Institute for the Study of Infectious Diseases, Tokio.
N.	Prof. G. H. F. Nuttall, F.R.S., Cambridge.
Schenkling	Prof. Schenkling, Deutsches Entomologisches Museum, Berlin-Dahlem.
Sweet	Dr Georgina Sweet, University of Melbourne, Australia.
Valerio	Prof. B. Galli-Valerio, Lausanne, Switzerland.
Zool. Soc.	Zoological Society of London.

Countries whence the species have not hitherto been recorded are marked by a *. In other cases new hosts and localities are given in countries whence specimens have already been derived. In compiling the record numerous specimens received by us have had to be excluded because they were not accompanied by sufficient data. The species of *Ixodes* are given in alphabetical order.

Ixodes acutitarsus (Karsch 1880). Previously recorded from Japan; Formosa and Sikkim, India (*Ticks*, II. p. 203). Add: (Ind. Mus. $\frac{1248}{17}$) 1 ♀ from Yambung, **India** (1100 ft) 13–17. I. 1912, S. W. Kemp coll.; (N. 3019) 1 ♀ from man, Hpimaw District, **Upper Burma***, 26. IX. 1914, F. K. Ward coll. (See *gigas* Warburton 1910, which is probably the ♂ of this species.)

Ixodes auritulus Neumann 1904. See this paper p. 312.

Ixodes bicornis Neumann 1906 (= *I. diversifossus* Nn. 1899?). Previously recorded from Mexico (*Ticks*, II. 187). Add: (N. 2811 = Berlin, 619/1913) 1 ♀ from *Nasua narica* (N. 2812 = Berlin 592/1913) 9 ♀ from *stag*, and (Berlin 150) 1 ♀ from *Equus caballus*, all from foot of Mt Turrialba, 1600 m. east of Cartago, **Costa Rica***, C. America, O. Garlepp coll.

Ixodes boliviensis Neumann 1904. Previously recorded from Bolivia (*Ticks*, II. 169). Add: (N. 2810 and 2813 = Berlin 592/1913) 2 ♀s from "*pisote*" and "*mapatsching*," foot of Mt Turrialba, 1600 m. east of Cartago, **Costa Rica***, C. America, O. Garlepp coll.

Ixodes brunneus Koch 1844. Previously recorded from Europe, Africa and N. America (*Ticks*, II. 190). Add: **Europe** (N. 2546) 1 ♀ from wagtail, *Motacilla lugubris*, near Pulborough, Sussex, England, 20. XI. 1913, S. Baxter coll. received from Dr A. F. R. Wollaston; (Berlin 191) 1 ♀ from *Turdus merula* Linn., Runowshina, Gouv. Poltawa, **Russia***, 28. III. 1906, Fovonoff coll. **Africa** (E. 150) 1 ♀ from dove, *Haplopelia johnstoni* Shelley, Mlange Mountain, Nyasaland, 5500 ft, V. 1910, S. A. Neave coll.; (N. 2157) 1 ♀ from hawfinch, *Coccothraustes C. buvryi*, Hammam Meskoutine, **E. Algeria***, 31. III. P. A. Buxton coll. **Asia:** (Berlin 219) 1 ♀ from "Steinhuhn," Northern **Persia***, Lemm coll.; (Berlin 163) 1 ♀ from *Hypsipotes amaurotus*, Yamanaka, Suruga, **Japan***, 1700 ft, 24. III. 1905, Hans Sauter coll.

Ixodes caledonicus Nuttall 1910. Previously recorded from Scotland (*Ticks*, II. 200). Add: **Scotland** (N. 1294) gorged ○ from dead starling, *Sturnus vulgaris*, Isle of May, Fifeshire, V. 1911, W. Evans coll.; (Ashworth 6) ○ from Greenland falcon, *Falco candicans*, Unst, 15. III. 1913, Dr J. H. Ashworth coll. **England***: (N. 1363) ♀ from head of starling, Sunderland, Co. Durham, 4. VI. 1908, Mr Duthrie coll., gift of Mr R. S. Bagnall; (N. 2979) ♀ from **Bosnia***, host unrecorded, collected by Roeschke, gift of Deutsches Entomologisches Museum, Berlin-Dahlem.

Note: The ♀ ○ and larva were described in *Ticks*, II. 198–200, Figs. 191–193 and the ♂ in *Parasitology* IV. 175–179, Fig. 1. The accompanying Fig. 21 illustrates the ♀ specimen from Bosnia; a comparison of this and my earlier figure shows a slight degree of individual variation in the shape of the basis capituli, scutum and spiracle which it is well to take into account. The dentition of the hypostome is more accurately shown in the present figure.

Ixodes canisuga Johnston 1849. Previously recorded from Scotland, England, Ireland, Germany, France. Add: **Scotland:** (N. 2380) ○s from *red deer*, R. Hancock coll. **England:** (N. 3155) 1 ♀ from *Passer domesticus*, Ingham, Statham, Norfolk, V. 1914, P. A. Buxton coll.; (N. 1371) from nest of starling, *Sturnus vulgaris*, Framlingham near Norwich, Norfolk, VI. 1911, Mr Piggott coll.; (Bagnall coll.) 3 ♀s from young *fox-hound*, Gebside, Co. Durham, 1911, R. S. Bagnall coll.; (N. 1302, 1303) ♂ ♀s ○s from nests and on young sand-martins, *Cotile riparia*, Cauldwell Hall Farm and Boyton Hall Farm, Suffolk, 11. VII. 1911, G. H. F. Nuttall coll.; (N. 1304) ♂s ♀s from sand-martin's nests, banks of River Severn, Shrewsbury, 29. VI. 1911, R. F. L. Burton coll. (the nest contained eggs, they had been flooded in winter and contained at

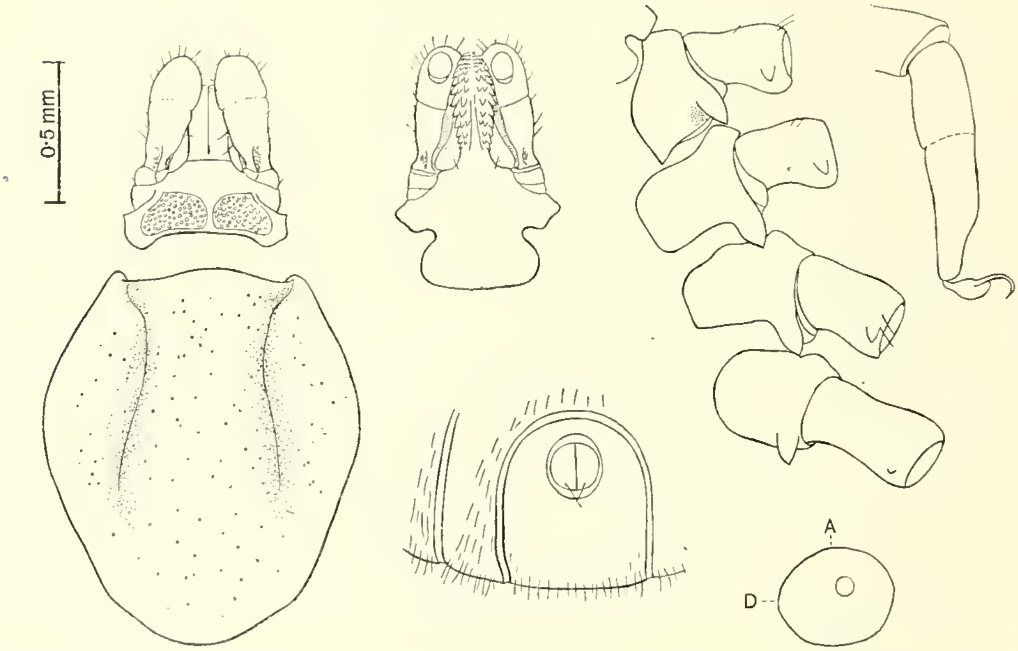

Fig. 21. *Ixodes caledonicus* Nuttall 1910, ♀ (N. 2979) from Bosnia (G.H.F.N. and D.S. del.).

least 100 ticks, which must have therefore fed on the adult birds), on 5. IV. 1911 Mr Burton collected (N. 1299) larvae from the nests; (N. 1730) ♀s from *dogs*, Tregothnan, Cornwall, where they infested the kennels, 12. VII. 1912, J. Dew coll. **Germany:** (N. 2815, from Berlin Mus.) 6 ♀s from young *foxes*, Nauen, Geheimrat Cohn coll. **Persia*:** (N. 2528) 2 ○s from *badger*, Ispahan, IV. 1913, Dr Donald W. Carr coll.

Ixodes cavipalpus Nuttall and Warburton 1907. Previously recorded from N.W. Rhodesia and Angola (*Ticks*, II. 194). Add: (N. 1601 = Liverpool 49*a*) ♂ ♀ from *cattle*, Mwiniwcynig Village, Sekwa River, **N. Nyasaland***, 13. II. 1909, J. B. Davey coll.

Ixodes eudyptidis Maskell 1885. Previously recorded from New Zealand (see *Ticks*, II, pp. 217, 291). We have since determined (N. 2068) 1 ♀ from *Sterna antarctica*, New Plymouth, **New Zealand,** 22. XI. 1909, W. W. Smith coll., gift of Prof. Charles Chilton; (H. 5) 1 ♀ 14 ○ from penguin, *Eudyptula minor*, Tollgates Island, s. coast of **New South Wales,** 28. IX. 1911, A. F. B. Hull coll.; (H. 46) 1 ♀ from *E. minor*, Long Bay, Sydney, N.S.W., 1914, H. S. Grant coll.; (H. 49) 1 ○ from *penguin*, **Flinders Island,** Bass Straits, Australia, Dr J. B. Cleland coll.

Ixodes fecialis Warburton and Nuttall 1909. Previously recorded from West Australia and Queensland (*Ticks*, II. 249, 250). Add: (N. 1847 = Cleland 14) two ○s from native cat, *Dasyurus viverrinus*, **New South Wales***, 22. I. 1912, Mr Steel coll.; (H. 10, 53) 4 ♀ from *D. viverrinus*, Sydney, 4. VII. 1912, H. S. Grant coll.; (J. 10) ♀ from *rat*, Sydney and (J. 8, 9, 17) 4 ○ from *D. viverrinus*, T. H. Johnston's slides.

Ixodes gigas Warburton 1910. Previously recorded from Darjiling District, E. Himalayas, but no host mentioned (*Ticks*, II. 204). Add: (N. 2946) 1 ♂ from *man*, in jungle, Salween Valley, 7–8000 ft., Chamuteng, **Tibet***, 1914, F. K. Ward coll. (probably the ♂ of *acutitarsus*, *q.v.*).

Ixodes hexagonus Leach 1815. Previously recorded from Scotland, England, Wales, Ireland, Belgium, Germany, France, N. Africa (Algeria), N. America (California, Kansas, Maryland), S. America (no country stated) (*Ticks*, II. 183). Add: **England:** (N. 1347) gorged ♀ from country *rat*, Brampton, Norfolk, VI. 1911, Mr Hammond coll.; (N. 1360) ♀ from *dog*, Whitehouse Farm, Parham, Suffolk, 3. X. 1911, C. Strickland coll. Cambridgeshire: (N. 1823) ♀ ○ from hedgehog, *Erinaceus europaeus*, Cambridge, 26. IX. 1912, G. H. F. Nuttall coll.; (N. 1241) ♂ from *hedgehog's nest*, Histon, 6. III. 1911, G. H. F. Nuttall coll.; (N. 1240)

♀s from ferret, *Mustela putorius*, Histon, 13. III. 1911, C. Warburton coll.; (N. 2724) ○ from otter, *Lutra vulgaris*, Cambridge, G. B. Hony coll., 27. II. 1914; (N. 3108) ♀ from weasel, *Mustela vulgaris*, Swavesey, 11. x. 1913, G. B. Hony coll.; (N. 1385) ♀ ○s ∠s from ferrets, *Mustela putorius*, Chatteris, 18. XI. 1911, A. Parkinson coll. W. Sussex; (N. 3182) ♀ from dog (?), Fryern, near Pulborough, 28. VII. 1915, E. King. Kent: (N. 3119) ○ from stoat, *Mustela erminea*, Fairhill, Tonbridge, XII. 1914, P. A. Buxton coll. Somerset: (N. 1239) ♀ from polecat, *Mustela putorius*, 2. III. 1911, W. Farren coll. Warwickshire: (N. 2327–2331) ♀s ○s from *stoats, ferrets* and *rat*, Little Packington, VIII. 1913, R. Cornish coll. **Wales:** (N. 2164) ♀ ○s ∠s from ferret, *Mustela putorius*, White House Farm, Gresford, near Wrexham, Denbighshire, 19. v. 1913, Miss G. D. Hay; (N. 2733) ○ from *fox*, Llanrhystyd, Cardiganshire, III. 1914, Prof. C. S. Walton coll. and (N. 3209) 1 ♂ apparently attached to the ear of a badger, *Meles taxus*, brought from Llanrhystyd, VI? 1915, to Messrs Hutchins, taxidermists (communicated by C. S. W. This is the first recorded instance of the occurrence of the ♂ upon a host). (N. 1916 = Zool. Soc. 34) from polecat, *M. putorius*, St Clears, Carmarthenshire, 9. x. 1912. **France:** (Brumpt 19) ♀ from *hedgehog*, near Paris, ca. 1910, M. Bessin coll. **Germany:** (Berlin 188*a*) ♀ from young *fox*, Nauen, no date recorded, Geheimrat Cohn coll. **Switzerland:** (N. 1700 = Valerio 2236) ♀ from *hedgehog*, Lausanne, 1908, Prof. Galli-Valerio coll. **Portugal*:** (N. 1591) ♀, host and place not stated, received IV. 1912 from Dr C. França, Lisbon. **Serbia*:** 1 ♀ from *bullock*, Nish, VI. 1915, J. E. M. Mellor coll. **N. America: British Columbia*:** (N. 1378) ♀ from *weasel*, Mt Lehman, 27. I. 1911, Dr S. Hadwen coll. **New Brunswick*:** (N. 1504) ♀ from *cat*, 19. XII. 1911, J. Birrel coll., gift of Hon. N. C. Rothschild.

Ixodes hexagonus var. **cookei** (Packard 1869). Previously recorded from N. America (U.S.A.: Maine, Texas, Colorado, District of Columbia, Iowa; Ontario, Canada) (*Ticks*, II. 184). Add: **N. America: British Columbia*:** (N. 2776) ♀ from dog, Mt Lehman, 4. v. 1914, Dr S. Hadwen coll. **California*:** (N. 2048) ♀ from *Putorius xanthogenys*, San Francisco, 1. IX. 1909, M. B. Mitzmain coll. (N. 2047, 2049, 2054) ♂ ♀ ○s ∠s from *P. xanthogenys*, San Mateo County, 7, 14 and 20. IX. 1909 respectively, M. B. Mitzmain coll.; (Mitzmain 10) ○ from *Callospermophilus* (*Citellus*) *chrysodeirus*, Sonoma County, x. 1909 and (Mitzmain 11) ○ from *Mephitis occidentalis*, San Francisco, 2. IX. 1909, M. B. Mitzmain coll. **Central America:** (Berlin 147) ○ from weasel, *Arctogale costaricensis* Goldm., Irazu, **Costa Rica***, 2800 m., O. Garlepp coll.

Ixodes holocyclus Neumann 1899. Previously recorded from Australia (Queensland, N. S. Wales, W. Australia) and E. India in *Ticks*, II. 237, 238. Add: From **New South Wales:** (H. 51) unfed ♀ from dead *girl's* head, Sirius Cove, Sydney, Dr A. W. Tange coll.; (H. 10) ♀s from *dog*, Quarantine Station, Sydney; (H. 20) ♀s from *monkey*, New Zoo., Sydney, 21. v. 1914, A. S. Le Souëf coll.; (H. 27) ♀s from arm of man, Illawarra District, 10. IV. 1914, L. Harrison coll.; (H. 14) ○s from *Perameles nasuta*, Sydney; (H. 52) ♀s from Underbrook, J. R. Fulton coll.; (H. 54) ♀ from child's ear; (N. 1846 = Cleland 12) ♀ from *man*, Sydney, XII. 1909, and (N. 1848) ♀ ○s from *Perameles nasuta*, 8. VIII. 1911, received from Dr J. B. Cleland; (N. 3089) ○ from *dog*, Eumundi, **Queensland,** 8. v. 1913, M. Hull coll.

Ixodes loricatus Neumann 1899. Previously recorded from Mexico, Brazil, Argentine, Tierra del Fuego, Paraguay (*Ticks*, II. 268). Add: (N. 2687) ♀ from "*gamba*," **Brazil,** XII. 1913, gift of Dr A. Carini.

Ixodes marxi Banks 1908. Previously recorded from Canada and United States (*Ticks*, II. 174). Add: (N. 2087) ♀s from *raccoon*, Montgomery County, **Alabama*,** III. 1913, received from Prof. C. A. Cary.

Ixodes oldi Nuttall 1913. Previously recorded from Sierra Leone (Nuttall, 1913, p. 135). Add: (N. 3200 = E. 932*c*) ♀s from *leopard*, near Chirinda, **S. Rhodesia*,** 3800 ft, 26. XII. 1909, C. F. M. Swynnerton coll.

Ixodes ornithorhynchi Lucas 1845. Previously recorded from Marianne Islands and Tasmania (*Ticks*, II. 242). Add: (Berlin 226) ♀ from *Ornithorhynchus anatinus*, **W. Australia*:** (N. 2984 = Sweet 257) 2 ♀, 4 ○s from *O. anatinus*, Australia, 17. IV. 1910, communicated by Dr Georgina Sweet; (J. 11–14) six ○s from *O. anatinus*, **Victoria*,** T. H. Johnston's slides.

Ixodes percavatus Neumann 1906. Previously recorded from Nightingale Island, Tristan d'Acunha group (W. of Cape of Good Hope) in *Ticks*, II. 221. Add: (N. 1850 = Cleland 17) ♀ from penguin, *Eudyptula minor*, Perth, **West Australia*,** 1908, received from Dr J. B. Cleland, Bureau of Microbiology, Sydney.

Ixodes percavatus var. **rothschildi** Nuttall and Warburton 1911. Type taken from puffin, probably in Great Britain. We are now able to record (N. 1736) ♀s and ○s found on dead *herring gull*, Perranporth, N.-W. Cornwall, **England*,** 15. VI. 1912, L. P. W. Renouf coll.

Ixodes pilosus Koch 1844. Previously recorded from Cape Colony and Orange Free State, Natal, Transvaal (*Ticks*, II. 225–226). Add from **N. Rhodesia***: (N. 2701*a*) ♀s from *hartebeest* and (N. 2702) ♂ ♀s from *grysbok*, at or near Mwengwa Station, XII. 1913, L. C. Heath coll.; **British E. Africa***: (E. 269) ♀ from *Felis capensis hindei* Wr., W. of foot of Aberdare Mts, 1. III. 1911, S. A. Neave coll., together with *I. rasus*[1]. **Nyasaland***: (E. 851–854) ♀s from *dogs*, and (E. 855) ♂ ♀s from "*oribi*," also (N. 2844 = E. 856) ♀ from *reedbuck*, S.W. of Lake Chilwa, I. 1914, S. A. Neave coll.; (N. 1323 = E. 227*f*) ♀ from *roan antelope*, Mpalali River, Marimba, 1. I. 1911, Dr J. E. S. Old coll.; (E. 690*c*) ♀ from *dog*, Seichenya River, Mlanje, I. 1913, S. A. Neave coll.; **German E. Africa***: (Berlin 33) from the foot of the high pasture lands, Bismarkhügel, above Marangu, south of Mawensi, ca. 3000 m., II. 1912, Prof. C. Schröder coll.; **Cape Colony**: (N. 1912, from Cooper coll.) ♂ ♀ from *cattle*, Starvation Camp, Gonubie Park, East London, II. 1911.

Ixodes putus (O. Pickard-Cambridge 1876). Previously recorded from Great Britain, N. and S. America (Islands off Newfoundland coast, Alaska, Tierra del Fuego) in the Antarctic, Asia and Australasia (Bering Island, Campbell Island, King Island, Kerguelen Island) (*Ticks*, II. 260–261). Add: **Wales**: (N. 1307 and 1703) all stages in plenty, but especially ♀s from in and about nests of *guillemots*, on cliffs overhanging the sea, Worms Head, Gower, Glamorganshire, 2. VII. 1911, G. H. F. Nuttall coll., 3. VII. 1912, G. Williams coll., used for raising experiments. **Kerguelen Islands,** the type locality: (N. 2799 = Berlin) ○ from ground, *Eudyptes* about, Deutsche Tiefsee Expedition, 1898–1899. **S. Pacific**: (N. 2722) ♀ from albatross, *Diomedea exulans*, **Antipodes Island***, 1907, Prof. W. B. Benham coll., received from Prof. Chas. Chilton.

We have examined numerous specimens collected by H. Hamilton of the Australian Antarctic Expedition (Mawson Expedition) at **Macquarie Island***: (1) sixteen ♀ from Royal penguin, *Catarrhactes schlegeli*, from back and head of young yearling which had just finished moulting, S. E. Harbour, 8. II. 1912, one ♀ had laid eggs from which larvae emerged; (2) ○ from the back of the head of a king penguin, *Aptenodytes patagonica*, The Nuggets, 21. I. 1912; (3) ♀ from cheek of adult Rockhopper penguin, *Pygoscelis papua*, The Nuggets, 29. II. 1912; (4) fourteen ♀ from Victoria penguin, *Catarrhactes pachyrhynchus* (on back of head and neck of yearling moulting birds), Rookery, Garden Bay, 15. II. 1912; (5) twelve ♀, three ○, three ∠ from head and breast of sooty albatross, *Phoebetria fuliginosa*, 5. XI. 1912; (6) larvae, from penguin sp., 1912; (7) ♂ ♀ apparently copulating, and ○, from under loose turf, near Shaggery, 2. VIII. 1912. **South Polar Region*:** (Berlin 363) ♀, Possession Island, Victoria Land, 25. XII. 1901.

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[1] Neumann (1913, p. 26) records *I. pilosus* from Brit. E. Africa as follows: ♂ from Molo, station 19, altitude 2420 m., XII. 1911; ♂ from Kijabé, station 27, altitude 2100 m., XII. 1911; ♀ from lower forests of Mt Kenya, altitude 2400 m., I. 1912. No hosts were recorded by the collectors Alluaud and Jeannel.

Ixodes rasus Neumann 1899. Previously recorded from the Congo, Cameroons, Ashanti, Togo, German East Africa, Uganda (*Ticks*, II. 230). Add: (N. 2480) ○ from *man*, Chercher Mts, 8000 ft, near Harrar, **Abyssinia***, Mr Armbruster coll., received from Dr G. Wherry, 1913; (E. 269*a*) ♀ from *Felis capensis hindei* Wr., W. foot of Aberdare Mts, **British E. Africa***, 1. III. 1911, S. A. Neave coll., with *I. pilosus* ♀; (Berlin 66) ♀ from Desema, Mombassa, 16. IX.—7. X. 1891, Conradt coll.; (Berlin 321) ♀ from Hinterland Alen, **Span. Guinea***, VII. 1906—I. 1907, Fessmann coll.; (Berlin 309) ♀ from woods between Victoria and the Naval Harbour, **Cameroon,** 19. IX. year?, Braem coll.; (N. 3005 = Berlin 325) ♀ from *wild pig*, Cameroon, Dr Schäfer coll.; (N. 2803 = Berlin 1600/07) ♀s from *Manis* sp., Lolodorf, 29. III. 1907; (Berlin 223*b*) ♀ from *wild pig*, Molundu, I. 1910; (N. 2353) ♀s from *goat*, Bubashero, **Belgian Congo,** 23. V. 1913, F. Harker coll.; (N. 3192 = E. 392*b*) ♂s ♀s from *leopard*, near Chirinda, **S. Rhodesia***, 3800 ft, 26. XII. 1909, C. F. M. Swynnerton coll.; (E. 762*a*) ♀ from *dog*, **Gold Coast,** 1913, A. E. Evans coll.

Ixodes ricinus (Linn.). Previously recorded from Europe (Scotland, England, Wales, Ireland, France, Belgium, Holland, Germany, Italy, Spain, Galicia, Albania, Rhodes, Russia, Finland), Africa (Algeria and Tunisia), Asia (Transcaucasia, Arabia, Japan), N. America (United States, British Columbia) in *Ticks*, Part II. 152–156. Add: **Scotland** (N. 3190) ♀ from *Lepus variabilis*, Tarvie, Pitlochry, N.B., 21. IX. 1915, P. A. Buxton coll.; (N. 2380*a*) ♀ from *red deer*, gift of R. Hancock, 1913; (N. 2777) ○, ∠ from *grouse*, gift of Dr A. E. Shipley, 1914. **England:** From Cumberland: (N. 3183) ♂ ♀ from *dog*, Wastwater, 2. IX. 1915 and (N. 3184) ∠s from *man* (caught creeping on my hand), Buttermere, 17–28. VIII. 1915, G. H. F. Nuttall coll. From Cornwall: (Liverpool 173) ♀s taken at Launceston, 25. X. 1907, R. Newstead coll. The following were taken on Lord Falmouth's estate, Tregothnan, near Falmouth (N. 1560) ♂ ♀ ○ ∠ in plenty from dying *deer*, 6. III. 1912, Hon. V. Boscawen; (N. 1576) ♂ ♀ ∠ from grass in deer park, and (N. 1677) ○ ∠ in plenty from ears and eyelids of wild *rabbits*, 17. iv. 1912, G. H. F. Nuttall, coll.; (N. 1729) ♀ ○s ∠ from *deer*, 12. vii. 1912, (N. 1807–1808) ♂ ♀ ○ ∠ in plenty from *deer*, 2. ix. 1912, J. Dew coll. **Wales:** (N. 2734) ♀ beneath skin of ear of *fox*, Llanrhystyd, Cardiganshire, iii. 1914, gift of Prof. C. S. Walton who has recently sent us the following specimens for determination, collected by him in Cardiganshire (N. 3205–3208): 5 ○ from nose of *sheep* and 1 ♀ from ear of ewe, 15. vi. 1915, Llyngwinan; 2 ♀ from *cat*, Crosswood, 24. v. 1915; he also sent 5 ○ from *squirrel*, brought vi. 1915, from Goginnan to Messrs Hutchings, taxidermists; (N. 1868 = Liverpool 181) ♂ ♀ from *cattle*, North Wales, x. 1906, Dr Arnnett coll. **Ireland:** (N. 1308) ♀s from *cattle* suffering from redwater, Athlone, Co. Westmeath, 28. iv.–3. v. 1911, H. W. Percy coll. (N. 2042″) ♂ ♀s from *Lepus timidus*, Waterford, 26. ix. 1905; (N. 1543) ♂ from clothing of *man*, Killarney, Co. Kerry, 9. ix. 1911, G. Patrick coll. **France:** From Chantilly (Brumpt coll., Paris) ○s on *hedgehog*, ♂ ♀ ○ on *deer*, x. 1909 and xi. 1909; ♂s ♀s from *Cervus capreolus* in the Paris Market, x. 1908, Dr E. Brumpt coll. **Norway*:** (N. 2236, 2272) ♂s ♀s from *cattle* with redwater, near Toensberg, Co. Jarlsberg and Larvick, and at Sundalen, Co. Romsdalen, W. Norway, collected vi. and vii. 1913 by Mr Kragerud and presented by Director Malm, Veterinaer Laboratoriet, Kristiania. **Germany:** From N. Schleswig-Holstein: (Knuth 8*a*) ♀ from *cattle*, Kreis Husum, 21. ix. 1913. From East Friesland: (Berlin 192) ○ from *Sciurus*, Friedeburg, 23. iii. 1912, Oberförster Pogge; (Knuth 2, 4) ♀s from *cattle*, Island of Juist, 6 and 22. xi. 1913. From Brandenburg: (N. 2997 = Berlin Mus. 352) ○s ∠s from *Lacerta muralis*, Schorfheide, Joachimstal, 8. vi. 1888, Möbius coll. (lizards preserved with ticks attached); (Schenkling 5) ♀ ○ from *dog*, Berlin; (Berlin 355) ♂s ♀ from *pheasant*, Finkenkrug, 2. vii. 1899, Kuhlgutz coll. From Silesia: (Schenkling 17, 20) ♂s ♀s, collected by Letzner, with no mention of host. From Württenberg: (Berlin 362) ♂ ♀ in woods near Schwäb. Gmünd, 4–14. v. 1908, Ad. Spaney coll. From Bavaria: (Berlin 359, 360) ♀s on stones at Adelsberg, 7. x., and on bushes at Assling, 20. ix. year?, both collected by Veshoeff. **Switzerland*** (N. 1701 = Valerio 724) ♂ ♀ from *Lepus timidus*, Château de Ripaille, Haute Savoie, 1904, and (N. 1702 = Valerio 413) ♀ from *dog*, Orbe, Canton de Vaud, 1901, received from Prof. Galli-Valerio. **Russia:** (N. 1743) ○s from *Lacerta agilis*, Kieff, iv. 1912, purchased from T. V. Sherrin; (N. 2062) ♀s from Moscow, vi. 1912, received from Dr E. J. Marzinowsky; (N. 3009 = Berlin 356)

○s from *Turdus merula* Linn., Rumoschina, Gouv. Poltawa, 15. iv. 1907; (Berlin 358) ♀ from *Lepus timidus*, Standort 76, Skorodnoe, Gouv. Kursk, F. Fofonoff coll. **Hungary***: (N. 1691) ♂s ♀s, from *Canis familiaris*, Budapest, vi. 1912 and (N. 1692) ♂ from *Cervus capreolus*, Budapest vi. 1912, Prof. von. Rátz coll., both received from Prof. F. Hutyra. **Serbia***: 1 ♀ from bullock, Nish, vi. 1915, J. E. M. Mellor coll. **Roumania***: (N. 1817) ♂s ♀s from *horses*, 1912, received from Prof. C. S. Motas, Bucharest. **Italy**: (N. 2544) ♂ ♀, probably from sheep and cattle, Maremma, received from Prof. A. Berlese, 1913; (N. 2736) ♂s ♀s from *cattle* in Slaughter House, Rome, some days after their arrival from Sardinia, received from Dr L. Lavarra, iii. 1914.

Africa: (N. 2160) ♀ from *crested lark*, Hammam Meskoutine, **E. Algeria**, 31. iii. 1913, P. A. Buxton coll.

Asia: From **Kashmir***: (N. 2929) ♀s from *Canis familiaris*, 1912, J. E. M. Mellor coll. From **Japan**: (Berlin 169) ♀ found at Kanagawa, 2. vii. 1905, H. Sauter coll.; (N. 2908*a* = Miyajima 2) ♀ ∠ from *horse*, Daisen, N.W. part of Central Japan, 2. viii. 1912, and (N. 2909 = Miyajima 3) ♂ ♀s from *horse*, Takanebe, Kiushiu, 5. vi.–12. x. 1913, received from Dr M. Miyajima.

N. America: (N. 1570) ♂ ♀ from *deer*, Berkeley, **California**, 1912, F. C. Clarke coll., received from Prof. W. B. Herms; (Hadwen coll.) ○ ∠ from *man*, Shawnigan Lake, Vancouver Island, 15. xi. 1910, E. M. Anderson coll., also ○ from *dog*, Duncan, **British Columbia**, 25. xii. 1910, D. Ashby coll., both received from Dr S. Hadwen.

Ixodes rubicundus Neumann 1904. Previously recorded from Cape Colony (*Ticks*, ii. 207). Add: (N. 2169*a*) ♀s from *dogs*, Broken Hill, **N. Rhodesia***, ii.–iii. 1913, E. A. Copeman coll. (*I. rubicundus* var. *limbatus* Nn. ♀s came from Congo Free State).

Ixodes schillingsi Neumann 1901. Previously recorded from German E. Africa and Mozambique. Add: (N. 2379) ♂ ♀s from *Colobus* monkey, 1913, R. Hancock coll.; (N. 2719 = E. 777) ♀ from *Colobus* monkey, Nairobi, **British E. Africa***, 1913, T. J. Anderson coll. (It is worthy of note that the types were found in G. E. Africa on *Colobus caudatus*.)

Ixodes tenuirostris Neumann 1910. Previously recorded from Scotland, England, Wales, Island of Rügen, Switzerland (*Ticks*, ii. 248). Add localities in **England**: (N. 1358) ♀s *Mus decumanus*, captured in hedge-bank, Pike's Farm, Dedham, Essex, 16. x. 1911, G. Merriman coll.; (N. 1359) ♀ from *Mus decumanus*, hedge-bank, Ashford's Farm, Rendham, Suffolk, 28. ix. 1911, C. Strickland coll.; (N. 3133) larvae from *Talpa europaea*, Shrewsbury, 22. xii. 1908, R. F. L. Burton coll.; (N. 2509) larva from ear of *Microtus arvensis*, Barton, Cambridgeshire, 20. x. 1913, P. A. Buxton coll.

Ixodes ugandanus subsp. **djaronensis** Neumann 1907. Previously recorded from German E. Africa and Abyssinia (*Ticks*, ii. 233). Add: (N. 2794 = Berlin 1325/04) ♂ ♀ from "Schira," Kilimandjaro, **G. E. Africa,** 3. v. 1907, Dr E. H. Förster coll.

Ixodes unicavatus Neumann 1908. Previously recorded from Scotland and England (*Ticks*, ii. 266). Add: From **Wales*:** (N. 2067) larva, from cormorant, *Phalacrocorax carbo* L., Anglesea, N. Wales, 23. ii. 1886, C. Oldham coll., gift of W. F. Cooper. From **S. Pacific Ocean*:** (N. 2722*a*) nymph, from albatross, *Diomedea exulans*, Antipodes Island, 1907, Prof. W. B. Benham coll., received from Prof. C. Chilton, New Zealand.

Ixodes vespertilionis Koch 1844. Previously recorded from Europe (Wales, Ireland, France, Spain, Italy, Germany, Austro-Hungary), Africa (Algeria), S. Australia (*Ticks*, ii. 276). Add: (N. 1594) ♀ from *Rhinolophus hipposiderus*, in cave, Cefn, **N. Wales,** 4. iv. 1896, Prof. R. Newstead coll. (this specimen, the first recorded in Great Britain, is referred to in *Ticks* ii. but insufficient data are given); (Berlin Mus. 193) ○ from *Rh. hipposiderus*, near Weisskirchen, Mähren, **N. Austria,** 19. ix. 1913, Dr Kowarzick coll.; (N. 2933) ♂, collected in **Bosnia*** by Roeschke, gift of Deutsches Entomolog. Mus.; (N. 3132) ♀ from *Vespertilio kuhli*, Algiers, **Algeria,** N. Africa, 8. i. 1915, Rivet coll., gift of Dr Edm. Sergent.

6. Remarks and Corrections relating to certain species of *Ixodes*.

Ixodes canisuga Johnston 1849. In *Ticks*, Part ii. p. 214, we unfortunately misquote Banks (1908, p. 32) as stating that this species occurs in N. America. We are indebted to Mr F. C. Bishopp for pointing out the error.

Ixodes cookei var. **rugosus** Bishopp 1911. We are in some difficulty about recognizing the validity of this variety. The examination of ♀ specimens of *I. cookei* Packard 1869, led us to the conclusion (*Ticks*, Part ii. 183) that they merely represented an American form of

I. hexagonus, we consequently degraded *cookei* to a variety: *I. hexagonus* var. *cookei*. In European *hexagonus* ♀ of which we have examined hundreds there is a considerable variation in the shape and rugosity of the scutum and the size of the porose areas; on the other hand the ♂ is so rare (we possess but three and there are none in the Museums of London, Paris, and Berlin) that we know nothing regarding its range of variability. Our experience of the European *hexagonus* ♀ would lead us to attach little value to the differences Bishopp makes out for his *I. cookei* var. *rugosus* ♀. This leaves a single ♂ upon which he bases the variety *rugosus*. It may well be that further experience will show that the males of *I. hexagonus* var. *cookei* show variation like the females.

Ixodes fecialis var. **aegrifossus** Warburton and Nuttall 1909 (*Ticks*, Part II. 250). Having recently examined a number of specimens (listed on p. 327) we have convinced ourselves that *I. fecialis* varies in the structure of the capitulum and scutum: the type and the supposed variety represent the extremes in variation. As intermediate forms occur we must condemn the variety.

Judged from specimens mounted in balsam, the nymph closely resembles the ♀; it remains to be described. The ♂ and larva are still unknown.

Ixodes nigricans Neumann 1908 (*Ticks*, Part II. 159). On further consideration we conclude that this species must fall into the long synonomy of *I. ricinus* (Linnaeus 1746); the slight structural differences we noted are merely individual and the very black colour is due to faulty preservation.

Ixodes pratti Banks 1908 and **Ixodes kingi** Bishopp 1911. In *Ticks*, Part II. 174, we stated that we had not seen the ♂ of *I. pratti* and cited Banks' description thereof verbatim and enclosed in quotation marks. In a footnote we remarked "The presence of large auriculae is indicated in Banks' figure, which is very inaccurate. We have not included the ♂ in our key, Banks' description being insufficient." On the other hand we described the purported ♀ of this species from a Californian specimen (N. 716, presented to us by the U.S. Dept. of Agriculture) which Banks had identified. As this specimen represented a new species and came to us labelled *I. pratti* by Banks himself, we saw no reason for not describing and figuring it as *I. pratti* ♀. Our book appeared in May 1911. In the month following, F. C. Bishopp (23. VI. 1911, pp. 201–204) published an account of a purported new species, *I. kingi*, of which he described the ♂ (hitherto unknown), and the ♀ which we had previously described as *pratti* from one of Banks' specimens. Bishopp stated that Banks confused two species: *I. pratti* and *I. kingi.* In a review of *Ticks,* Part II. written subsequently by Bishopp (XII. 1911, p. 565) the latter states that our description of *pratti* Banks ♀ is clearly that of *kingi* Bishopp ♀; that Banks' purported ♂ *pratti* was *I. ricinus* var. *scapularis* ♂, leaving still a third species the true *pratti* Banks ♀. Bishopp observes that "consequently Nuttall and Warburton's description of neither sex applies to *Ixodes pratti.*" In making this statement, Bishopp is wrong in saying that we described the purported *pratti* ♂.

It is clear that there has been confusion, but the validity of Bishopp's species must remain in doubt until the true relation of the specimens is made clear. If, as it appears, Bishop found three species in Banks' type material of *I. pratti,* it is for him to give the full illustrated description of *pratti* and *kingi.* We should like to know how Bishopp decided which was which. If we accept his opinion, then the true *pratti* has never been adequately described.

Finally I should like to know how the matter stands in relation to the *priority of names.* If (1) Banks confused three species in his description and figures but (2) nevertheless sent us a specimen which he recognized as *I. pratti* and (3) we described it as *I. pratti* Banks 1908, does not this name, published in May 1911, invalidate the name *I. kingi* Bishopp, published in June 1911? Perhaps Messrs Banks and Bishopp will help me to clear up the point.

What we described as *Ixodes pratti* Banks ♀ occurs also in **Canada,** for we have determined (N. 1377) 1 ♀ from *dog,* Milk River, Alberta, VII. 1911, A. Watson coll., gift of Dr S. Hadwen.

7. LIST OF NEW SPECIES AND VARIETIES OF *IXODES* AND OF SPECIES NOT HITHERTO RECOGNIZED OR INCLUDED IN *TICKS,* PART II.

The following list of species supplements the one given in the Index to *Ticks,* Part II.; the two lists comprise all the known species of *Ixodes.* The new species described in this paper are included in the following list.

Ixodes

alluaudi Neumann 1913, ♂, from German East Africa (Neumann, 1913, pp. 26–28, Figs. 1, 2).

anatis Chilton 1904, ♀ ○, from duck, New Zealand, redescribed in this paper, p. 317.

angustus var. *woodi* Bishopp 1911, ♀, from woodrat, *Neotoma micropus,* Texas (Bishopp, 1911, p. 205, Pl. II, fig. 13).

banksi Bishopp 1911, ♀, from muskrat, *Fiber zibethicus*, Arkansas (Bishopp 1911, 200, 201, Pl. II, figs. 3–6).

cookei var. *rugosus* Bishopp 1911, ♂ ♀, from dogs, Oregon and California (Bishopp 1911, pp. 197–199, Pl. II, Figs. 1, 2). See remarks on p. 334.

daveyi Nuttall 1913, ♀, from bird, Uganda (Nuttall, 1913, pp. 133–135, Fig. 2).

dentatus var. *spinipalpis* Hadwen and Nuttall 1915, ♀ ○ ∠, described in this paper, p. 301.

eichhorni Nuttall 1915, ♀ ○, from bird and man, New Guinea, described in this paper, p. 295.

granulatus Supino 1897, ♀, from Burma. Species redescribed in this paper, p. 315.

kempi Nuttall 1913, ♀, from *Sciurus*, India (Nuttall, 1913, pp. 131–133, Fig. 1).

kingi Bishopp 1911, ♂ ♀, from badger, *Taxidea taxus*, Wyoming, etc. (Bishopp, 1911, pp. 201–204, figs. 7–12). See discussion in this paper, p. 335.

nairobiensis Nuttall 1915, ♀, from dog, Brit. E. Africa, described in this paper, p. 299.

nuttalli Lahille 1913, ♂ ♀ ○ ∠, from vizcacha, Argentina and Peru, redescribed in this paper, p. 307.

oldi Nuttall 1913, ♀, from bushcat, Sierra Leone (Nuttall, 1913, pp. 135, 136, Fig. 3).

ricinoides Nuttall 1913, ♀, from deer, China (Nuttall, 1913, pp. 136–138, Fig. 4).

ricinus var. *gibbosus* Nuttall 1915, from goats, Asiatic Turkey, described in this paper, p. 300.

victoriensis Nuttall 1915, ♀, from wombat, Australia, described in this paper, p. 297.

The geographical distribution of the foregoing 13 species and 4 varieties is as follows:

Asia: *eichhorni, granulatus, ricinoides, ricinus* var. *gibbosus* (4).

Africa: *alluaudi, daveyi, kempi, nairobiensis, oldi* (5).

America: *angustus* var. *woodi, banksi, cookei* var. *rugosus, dentatus* var. *spinipalpis, kingi, nuttalli* (6).

Australasia: *anatis, victoriensis* (2).

REFERENCES

The reader is referred to *Bibliography of the Ixodoidea*, Part I, 1911 (2004 titles), by Nuttall, Robinson and Cooper, and Part II, 1915 (462 titles), by Nuttall and Robinson. Cambridge: University Press.

The paper by Nuttall (1913) appeared in *Parasitology*, VI.

Ticks, a Monograph of the Ixodoidea, Part II. The Genus Ixodes (1911) by Nuttall and Warburton, pp. xix + 105–348, 4 plates and 292 text figures. Cambridge: University Press.

MALLOPHAGA FROM MARSUPIALS. I.

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and T. HARVEY JOHNSTON, M.A., D.Sc.,
University of Queensland.

(With 14 Text-figures.)

This communication is the first of a series dealing with Mallophaga from Australian marsupials. We had hoped to prepare a single monographic work on the Family Boopidae, but the carrying out of this plan has been prevented by a variety of causes, and we think it advisable to publish piecemeal the notes and descriptions that we have accumulated during the last six years. There has of late years been a recrudescence of interest in the Mallophaga, and a considerable number of students are now investigating the group. Little has been published upon the very distinct family which is characteristic of Australian marsupials, and it is important that students of the group should have diagnoses of the family, sub-families, and genera, based upon an ample material, which includes all the known species, with a single exception, and more than an equal number of undescribed new forms. Such a material is at our disposal. Apart from our own collections, Mr A. S. Le Souëf has very kindly transferred to us all his Mallophaga from marsupials, including his types.

Some structural features, of which use is made in the diagnoses of the family and its lesser groups, but which are not enlarged upon in the descriptions of species, will be dealt with more fully in a forthcoming morphological work by one of us (L. H.). Host-lists, and complete keys to the species of *Boopia* and *Heterodoxus*, will be included in the last paper of the series.

Family BOOPIDAE Mjöberg (1910, p. 21).

Mjöberg (*loc. cit.*) has given a diagnosis of this family, based upon his own species, *B. peregrina*, from an otter, *Lutra pruneri*, and upon Piaget's descriptions of *B. tarsata* (1880, p. 599) and *B. grandis* (1885, p. 154). The chief character upon which we rely to separate the family from all other Mallophaga is the presence of a large accessory sac of unknown function in connection with the ♂ genitalia. This sac is not figured by Mjöberg for *B. peregrina*, and Dr Mjöberg, who has seen our preparations of all other genera of Boopidae, assures us that it is not present. There is thus some doubt as to whether *B. peregrina* should be included in *Boopia* at all, although in every other respect it appears to conform.

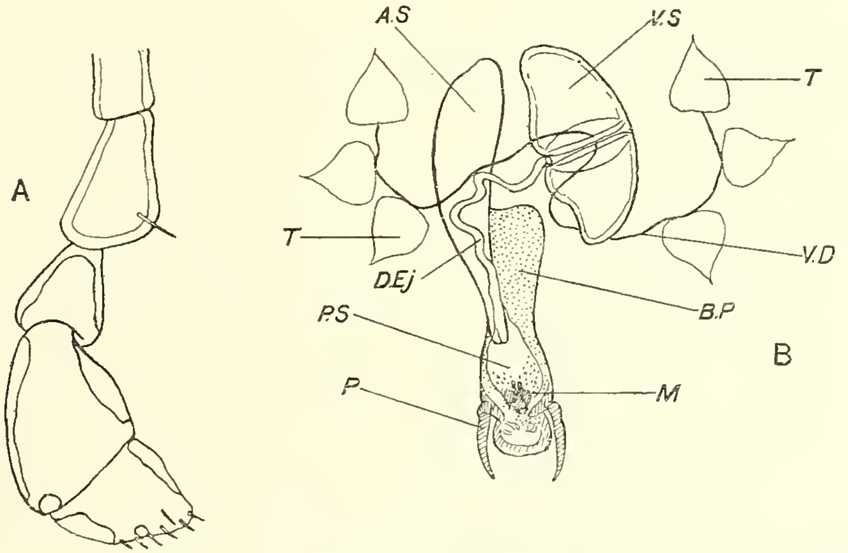

Fig. 1. Family Boopidae. (A) Antenna of *Paraheterodoxus insignis*, (B) ♂ genitalia of Boopidae, schematic. *A.S.* Accessory sac, *B.P.* Basal plate, *D.Ej.* Ejaculatory duct, *M.* Mesosome, *P.* Paramere, *P.S.* Preputial sac. *T.* Testes. *V.D.* Vasa deferentia, *V.S.* Vesicula seminalis. (L. H. *del.*)

The family may be briefly diagnosed as follows: Amblycera with head broader than long; antennae definitely five-jointed; thorax relatively long; prothorax transversely ellipsoid, with lateral expansions; mesothorax distinct, with a pair of dorsal prominences, each bearing a spine, or a long hair; hairs generally stouter, and of a more spinous character than in bird-frequenting Amblycera; abdominal stigmata on segments 2–7, not 3–8; ♂ genitalia with vesicula very broad in proportion to its length, and with a large accessory sac without homologue in other Mallophaga. Characteristic of marsupials.

This family we divide into two sub-families, Latumcephalinae, and Boopinae, which are easily separable by the following key.

Key to Sub-families.

A. Palpi two-jointed LATUMCEPHALINAE.
AA. Palpi four-jointed BOOPINAE.

Sub-family LATUMCEPHALINAE n.

Characters of sub-family. Boopidae with head twice as broad as long; antennary fossa covered dorsally by a thin membranous plate; a tubercle with a movable spine protecting eye; palpi two-jointed; tarsi short and two-jointed; mesothoracic prominences with hairs, not spines. A single genus, *Latumcephalum* Le Souëf.

Genus *Latumcephalum* Le Souëf.

Le Souëf (1902, p. 51) has given a brief diagnosis of this genus, in which he states, *inter alia*, that the palpi are "apparently two-jointed, but in reality four-jointed." We find that the palps have only two articles. The characters we give for the sub-family hold equally for the genus. We may, in addition, draw attention to the extreme lateral production of the anterior temporal angle; to the unusual position of the eye, which is not marginal, but situated dorsal to the innermost part of the antennary fossa; to the development of the prothoracic wings at the expense of the median portion; and to the lateral incisions which divide the metathorax into two unequal parts. *Latumcephalum* is also devoid of the three pairs of special sensory organs (Fig. 4) which appear upon the first three abdominal segments of all other Boopidae. Two species are known, *L. macropus* Le Souëf, and *L. lesouëfi*, a new species which we describe below.

Latumcephalum macropus Le Souëf. Figs. 2–3.

Le Souëf (*loc. cit.*) has recorded this species from "wallabies," and has given a summary description and a poor figure (Fig. 4) of the ♀. He did not distinguish between the two species. We find the correct host of the type to be *Macropus dorsalis* (a Queensland species) in the Melbourne Zoological Gardens. The description and figures are from Le Souëf's types in our possession.

Description of the ♂. Head twice as wide as long, roughly parabolic in front, with squared temporal lobes and slightly concave occipital margin; anterior portion, in front of palps, sharply marked off from remainder by a pair of distinct indentations; antennary fossa very deep, with projecting anterior angles; and covered dorsally by a fine hyaline ridged plate, with its free edge serrated; the lateral margin of this plate completely bridges the fossa, giving an apparently continuous outline to the margin of the head, but there is a deep, narrow indentation before and behind it; temporal lobes truncated; palpi two-jointed, not four-jointed, as stated in the original description; the proximal joint cylindrical, the distal somewhat swollen, with rounded extremity bearing a few short hairs; the two segments of equal length; antennae capable of free projection beyond the margins of the head, of five segments; first short, second with cylindrical base and almost spherical distal portion, with a few slight projections on the distal border; third pedunculated, conical, with a concave extremity for reception of the fourth; fourth segment rounded and swollen, inverted distally to receive the irregularly conical fifth, which bears a fringe of bristles; eye dorsal, in

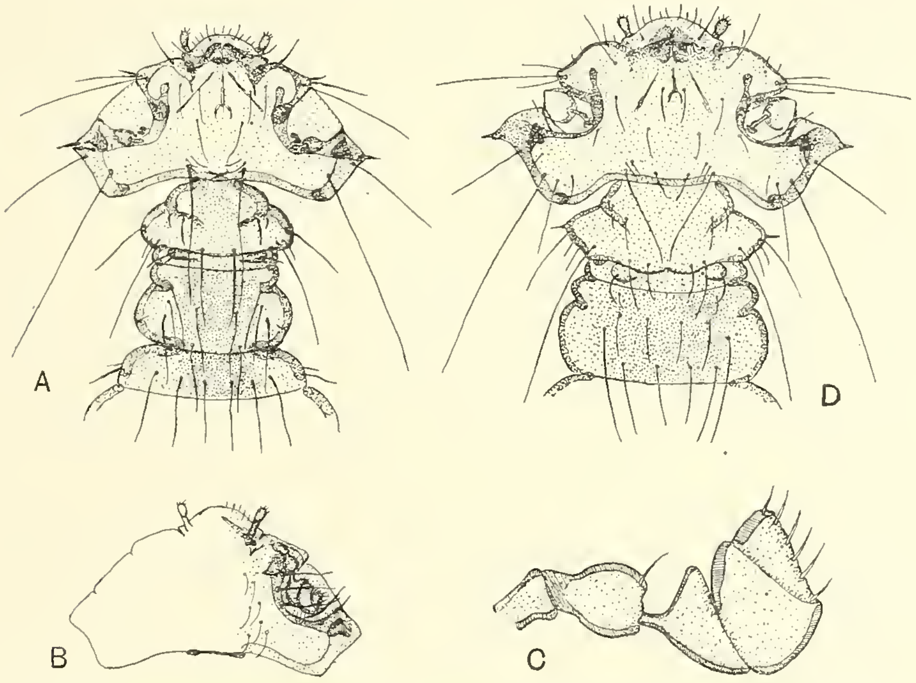

Fig. 2. *Latumcephalum macropus.* (A) Head and thorax, (B) Under side of head, (C) Antenna. *L. lesouëfi.* (D) Head and thorax. (L. H. *del.*)

posterior angle of fossa, small, with a double pigment spot; protected dorsally by a chitinous tubercle set just behind it, which bears in a socket on its summit a stout skittle-shaped spine; general colour pale yellowish, with strong chitinisations round the greater part of its margin, the relations of which are best seen in the figure; at the base of the palps is a strong chitinous support, which ends ventrally in a prominent tooth-like structure; immediately in front of the clypeal suture is a small rounded dorsal prominence; from the suture a strong chitinous band extends laterally, following the inner margin of the antennary fossa, thence round the temporal lobes and along the occiput; chitinisation very strong at the posterior lateral angles, with strong, tooth-like ventral projection; a similar, but weaker projection ventrally behind the insertion of the antenna; chitin band narrower along occiput; delicate hairs scattered round anterior part of head; a strong pustulated hair, and two shorter ones, at the anterior angle of the antennary fossa; lateral temporal angle with a stout short spine and a long hair; a long pustulated hair immediately in front of the posterior temporal angle, behind which is a tooth-like spine projecting inward and upward dorsally; in the mid-region of the dorsal surface, a few fine hairs, two longer ones, near the occipital margin, reaching to the metathorax; numerous small hairs on the ventral surface, and a stronger fringe along the inner border of the antennary fossa, which is not covered ventrally.

Prothorax about half as long and half as wide as head, transversely elliptical, with lateral expansions and obtusely rounded hind margin; strongly coloured on the antero-lateral borders, with oblique bands converging toward the mid-line posteriorly; four long and some short hairs along posterior margin, and a hair in lateral angles; a few scattered hairs on dorsal, and two pairs of long hairs on ventral surface. Mesothorax short, with rounded lateral borders, narrower than prothorax, with distinct suture; on dorsal surface two rounded prominences laterally, each bearing a couple of hairs; two pairs of long hairs on ventral surface. Metathorax of irregular shape, narrower anteriorly, and bilobed laterally; posterior margin flatly rounded, with crenated edge; practically uncoloured, save for narrow lateral bands; six pairs of long and some short hairs dorsally; two pairs on ventral surface; sternal markings distinct, comprising a roughly rectangular presternite, a papilionaceous mesosternite, and a rounded metasternite, with four internal chitinous spots, two in front and two behind the insertions of the metathoracic legs.

Abdomen of nine segments, elongate elliptical; widest at segments four and five; angles rounded and somewhat projecting; cuticle in general thrown into delicate ridges; lateral blotches yellow, with uncoloured space between them and margins of segments; transverse blotches also yellowish, and confined to the centre of the abdomen, leaving wide uncoloured spaces on either side; a hair in each lateral angle; six hairs dorsally on segment one; two rows, of about four and eight respectively, on the next seven; posterior extremity rounded, with several hairs; chitinous genitalia complex, and of same general form as in *Heterodoxus* and *Boopia*; ventral surface has hairs distributed in much the same manner as the dorsal; legs weak, uniformly coloured pale yellow, with stout hairs at the distal end of the tibia; tarsi short, two-jointed, with first joint a little shorter and stouter than second.

Measurements in millimetres.

	♂		♀	
	Length	Breadth	Length	Breadth
Head	0·210	0·403	0·218	0·412
Prothorax ...	0·090	0·202	0·111	0·218
Mesothorax ...	0·020	0·118	0·022	0·134
Metathorax ...	0·115	0·225	0·120	0·243
Abdomen ...	0·773	0·454	0·806	0·450
Total length and greatest breadth	1·210	0·454	1·277	0·450

The female differs from the male only in the posterior end of the abdomen, the final segment ending flatly with a fringe of hairs, and a pair of projecting gonopods, as in *Boopia*.

Found on *Macropus dorsalis* (a Queensland species) in the Melbourne Zoological Gardens, Le Souëf collection. The description and figures are from Le Souëf's type in our possession.

Latumcephalum lesouëfi n. sp. Figs. 2–3.

Amongst the mounted material in the Le Souëf collection was a slide containing three specimens of a *Latumcephalum* labelled *L. macropus*, from *Macropus ualabatus*, Victoria. We find, upon examination, that it is quite a distinct form, the main points of difference being in the shape and size of the plate covering the antennary fossa, the relatively broader abdomen, and distinctly wider thorax. We have named the species in compliment to Mr A. S. Le Souëf, who is both the author of the genus and the collector of the species.

Description of ♂. Like the last species, but with head and thorax proportionately larger; head with a more indented outline, due to the fact that the dorsal plate covering the antennary fossa is roughly triangular, instead of quadrangular; the apex projecting above the fossa, and giving an indentation in the outline on either side; the tubercle and spine protecting the eye are, in this species, borne upon this plate, and not on the chitinous framework of the fossa; posterior angles of temporal lobes projecting more prominently backwards behind the occiput; prothorax almost half as wide again, and has a more transversely elongate appearance; metathorax of same general character, but relatively wider, and a little longer; abdomen similar, but relatively broader; posterior extremity similar.

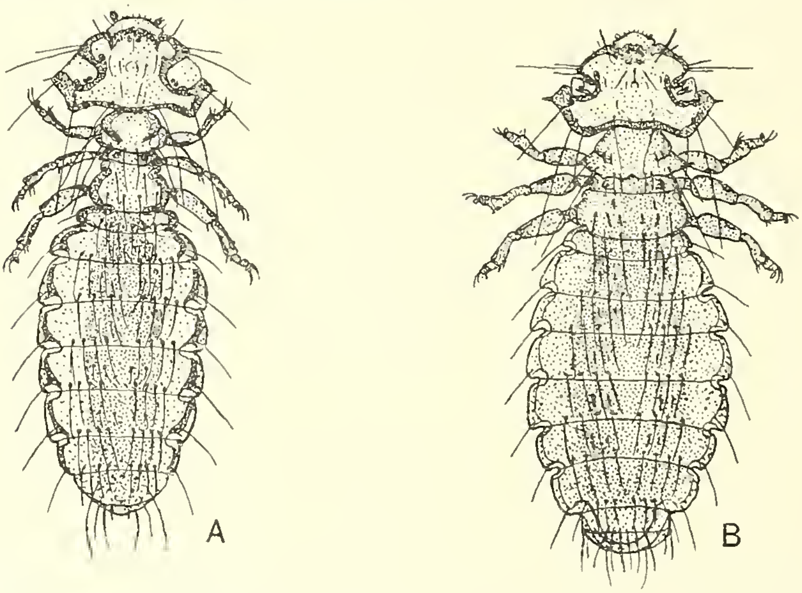

Fig. 3. (A) *Latumcephalum macropus*, ♂; (B) *L. lesouëfi*, ♂. (L. H. *del.*)

Measurements in millimetres.

	♂ Length	♂ Breadth
Head	0·235	0·470
Prothorax ...	0·115	0·271
Mesothorax ...	0·020	0·138
Metathorax ...	0·140	0·295
Abdomen ...	0·800	0·538
Total length and greatest breadth	1·310	0·538

The only female at our disposal is immature, but indicates the same sexual dimorphism as in *L. macropus*.

On *Macropus ualabatus*, Victoria, Le Souëf collection.

Sub-family BOOPINAE n.

Characters of sub-family. Boopidae with four-jointed palps, and long, two-jointed tarsus. Antennary fossa always bounded above and below by chitinous plate-like expansions of the sides of the head, both deeply cleft about the middle of their length. The eye is situated in the dorsal plate, just behind the cleft. Mesothoracic prominences always with stout spines. Three pairs of special sensory organs upon the first three abdominal segments.

Three genera are known, *Boopia* Piaget, *Heterodoxus* Le Souëf and Bullen, and *Paraheterodoxus* here described as new. The three may be easily distinguished by means of the following key.

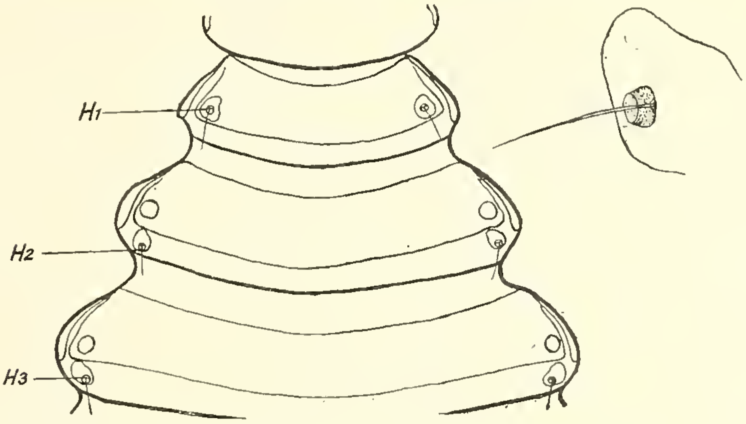

Fig. 4. First three abdominal segments of *Heterodoxus longitarsus*, to show special sensory hairs (H_1, H_2, H_3). (L. H. *del.*)

Key to the Genera of Boopinae.

A.	Without dagger-like spines beneath head	*Boopia.*
AA.	With dagger-like spines beneath head ...	B.
B.	Spines rising from base of palps	*Heterodoxus.*
BB.	Spines rising from throat beneath occiput	*Paraheterodoxus.*

Genus *Boopia* Piaget.

The genus *Boopia* has been well enough characterised by Piaget (1880, p. 599), but we would emphasise the special features which distinguish this genus, which comprises more species than any other of the family, from the bird-frequenting forms. These features are possessed in common by the remaining genera of the family, but *Boopia* *looks* distinct to the ordinary systematist, while *Heterodoxus* has been included in *Menopon* by Piaget, and only grudgingly allowed generic rank by Neumann (1913, p. 634), because of its superficial resemblance to the latter genus. We wish, therefore, to lay stress on the homogeneity of the Boopidae, and on the wide gulf which separates this family from the Menoponidae, and other bird-infesting Amblycera on the one side, and from the Trimenoponidae of rodents on the other.

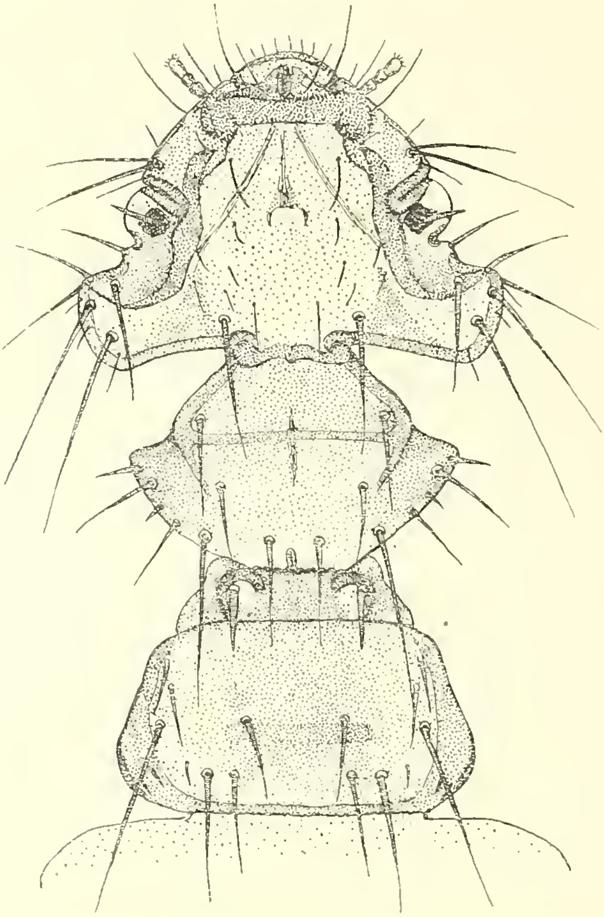

Fig. 5. *Boopia notafusca*, head and thorax. (L. H. *del.*)

These points of difference will be dealt with fully in a forthcoming morphological paper by one of us (L. H.). Here we simply repeat that they consist essentially in the structure of the ♂ internal genitalia, and in the structure, not the mere possession, of the distinct mesothorax. The close relation between *Boopia* and *Heterodoxus* is further emphasised by their possession in common of three pairs of sensory organs upon the first three abdominal segments.

Boopia is easily distinguished from *Heterodoxus* by the absence of the characteristic spines on the under side of the head, by the emargination of head outline posterior to the eye, and by the truncated temporal lobes. Twelve species are known to us at present, including the dubious *B. peregrina*; of which, in this communication, we redescribe *B. notafusca* of Le Souëf, and describe three new species.

Boopia notafusca Le Souëf. Figs. 5–6.

Le Souëf (1902, p. 50, Fig. 1) has given a summary description and a figure of no diagnostic value of this species. Our figures have been prepared from his type. Fig. 5 shows the character of the head and thorax, and serves to illustrate the genus as well as the species. Fig. 6 is an uncorrected camera drawing of the type ♂.

Description of ♂. Head broader than long, with very square temporal lobes, the posterior temporal angles, in specimens not subjected to compression, projecting behind the occiput. Eye large, simple. Prothorax two-thirds as long as wide, with lateral angles at about the middle of its length, narrow anteriorly and posteriorly. Mesothorax short, with lateral prominences bearing stout spines. Metathorax the width of the prothorax, widest close to its hind margin, shorter than the prothorax, with rounded angles. Abdomen broadly ovate, widest at the fourth segment, terminating in a narrower roundly conical last segment. Legs long, the second tarsal joint especially so. This joint exhibits a delicate transverse ridging upon its inner face, and is without an appendage. The general nature of the chaetotaxy will be apparent from the figures.

The ♀ differs from the ♂ only in being slightly larger, and in the posterior end of the abdomen, which shows two curved gonopodial processes.

Measurements in millimetres.

	♂		♀	
	Length	Breadth	Length	Breadth
Head	0·286	0·410	0·286	0·410
Prothorax ...	0·202	0·319	0·206	0·325
Mesothorax ...	0·050	0·202	0·050	0·218
Metathorax ...	0·218	0·370	0·225	0·385
Abdomen ...	1·092	0·790	1·273	0·807
Total length and greatest breadth	1·848	0·790	2·040	0·807

The species thus briefly characterised falls into that group within the genus which has hairs only, and no spines, upon the occiput. In this group it is further distinguished by the backward production of the temporal angles behind the occiput (the figures, owing to pressure used in mounting the specimen drawn, do not sufficiently indicate this character), while the character of the inner face of the second tarsal joint finally distinguishes it from the one species with which it might be confused.

Our specimens are from *Macropus ualabatus* and *M. giganteus*, both from Victoria, Le Souëf collection. The former would seem to be the more characteristic host.

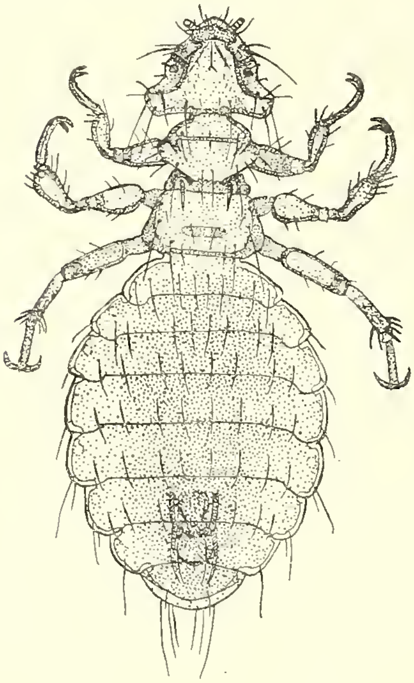

Fig. 6. *Boopia notafusca*, ♂.
(L. H. *del.*)

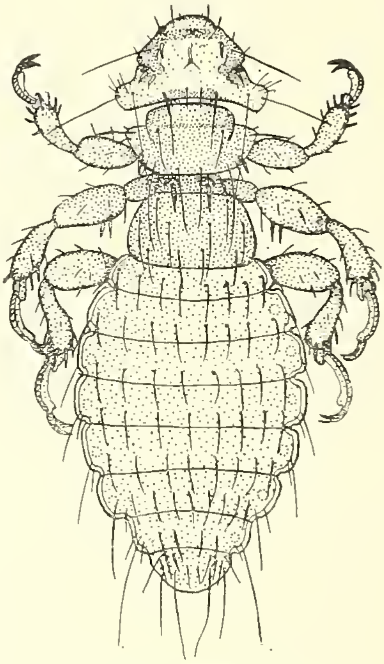

Fig. 7. *Boopia phanerocerata*, ♂.
(L. H. *del.*)

Boopia phanerocerata n. sp. Fig. 7.

Description of ♂. Head of the same general shape and proportions as *B. notafusca*, but with temporal angles more rounded, and temporal lobes not so markedly produced backwards behind the occiput. The eye is not so prominent, the pigment spot being extremely small; and the eye is not bounded posteriorly by a cleft. The strong hair behind the eye in *B. notafusca* is here represented only by a minute prickle; and the head outline presents an even curve from eye to anterior-temporal angle. The ocular spine is short and very stout; and a similar pair of short stout spines overlies the bases of the palps. The prothorax more resembles that of *Heterodoxus*, the expanded portion being semicircular; while the central portion does not taper anteriorly as in *B. notafusca*. The second and third hairs from the lateral angle have the form of short stout curved spines. The meso- and metathorax have the same general form and chaetotaxy as in *B. notafusca*. The second tarsal joint is without the minutely spinous ridges on the inner face which characterise the last species. The femora of the second legs bear upon the post-axial surface, close to the trochanter, a pair of specialised spines similar to those of *Paraheterodoxus* mentioned below; and presumably having a clasping function. The abdomen and genitalia are of the same general form as in *B. notafusca*.

The ♀ exhibits the usual sexual dimorphism of the hind end of the abdomen, is without the spines upon the second femora, is slightly larger, and generally stouter in all measurements.

Measurements in millimetres.

	♂		♀	
	Length	Breadth	Length	Breadth
Head	0·252	0·420	0·252	0·438
Prothorax ...	0·168	0·353	0·185	0·370
Mesothorax ...	0·067	0·269	0·069	0·070
Metathorax ...	0·185	0·336	0·204	0·375
Abdomen ...	0·857	0·638	0·950	0·706
Total length and greatest breadth	1·529	0·638	1·660	0·706

This small form we obtained in enormous numbers upon a long-nosed bandicoot, *Perameles nasuta*, caught at Woolloomooloo, Sydney, which must have been the last survivor of its tribe in this now busy shipping centre. There must have been many thousands of this parasite upon it. We have named the species from the very active way in which it oscillates its antennae, and brings them into view, when alive. It belongs to a group which also includes *B. tarsata* Piaget, and *B. uncinata* next described, and which is distinguished from the *notafusca* group by the shape of the temporal lobes, which are not produced backwards behind the occiput. It is easily separated from the other two species of the group by the fact that the eye is not bounded posteriorly by a cleft.

Boopia uncinata n. sp. Fig. 8.

Description of ♀. Head short in proportion to its length, projecting strongly in front of eye; the latter prominent, with large pigment spot and short thick curved spine, bounded posteriorly by a shallow cleft, from the bottom of which the anterior margin of the temporal lobe runs in a straight line to the angle. Both temporal angles rounded, the head at the posterior being decidedly narrower than at the anterior angles. Prothorax has the same general proportions as *B. phanerocerata*, but the semicircular hind margin is emarginate between the lateral hairs. The usual row of four hairs occurs upon the hind margin, but the wings carry only three heavy hook-like spines on each side. In the metathorax the outer pair of hairs of the posterior row is modified into a pair of short spines; and there is an indication of the inclusion of an abdominal tergite with the metathorax. The abdomen is narrow in proportion to its length, and ends dorsally in a single pair of gonopodial processes. The broadly rounded terminal sternite extends behind and laterally beyond the tergite.

Male unknown.

Measurements in millimetres.

	♀	
	Length	Breadth
Head	0·235	0·403
Prothorax ...	0·176	0·360
Mesothorax ...	0·060	0·202
Metathorax ...	0·202	0·353
Abdomen ...	1·092	0·806
Total length and greatest breadth	1·765	0·806

Described from one ♀ and one ⊙ taken upon a "tiger cat," *Dasyurus maculatus*, at Sydney. The species differs from *B. phanerocerata* in having the eye bounded posteriorly by a cleft; and from *B. tarsata*, besides the marked difference in size, in having no appendage upon the second tarsal joint.

Boopia spinosa n. sp. Fig. 9.

Description of ♀. Head broad in proportion to its length, with square temporal lobes, large and prominent eye, bounded posteriorly by a shallow cleft, and broadly rounded anterior portion. A pair of stout spines upon the occipital margin, enclosing four hairs, the outer pair long, the inner short. Prothorax almost as wide as head, with obtusely rounded lateral angle, the wing carrying four stout curved spines, three marginal, and one internal at the angle. From the lateral angles the sides converge slightly backwards to the third marginal spine, at which a slight angle is formed, and from this point the hind margin is broadly rounded. The metathorax is twice as broad as long, and has the outer hairs of the posterior row spinous. The abdomen is broadly ellipsoidal, widest at the fourth and fifth segments, with the dorsal gonopodial processes large and separated by a much wider interval than in the last species. The chaetotaxy conforms to the usual character in *Boopia*, each tergite carrying a single row of eight hairs, divided into a median row of four, and two lateral pairs; but in this species the median row is divided so as to give the appearance of four pairs. The sternites bear two rows of hairs, the anterior short, the posterior long. The first abdominal segment bears upon its lateral margin, at about half its length, a short stout spine.

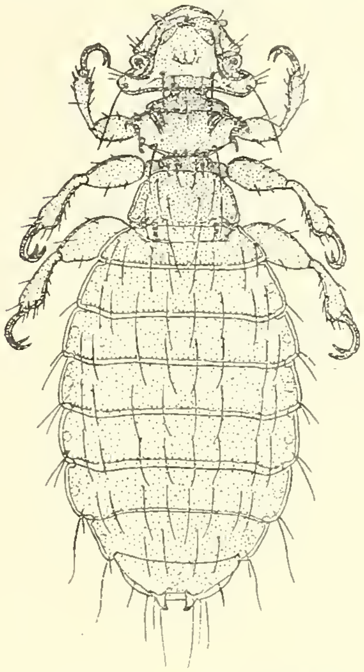

Fig. 8. *Boopia uncinata*, ♀.
(L. H. *del.*)

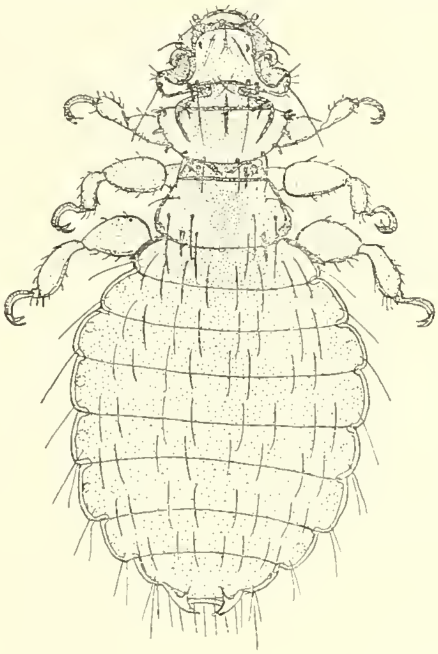

Fig. 9. *Boopia spinosa*, ♀.
(L. H. *del.*)

The ♂ differs from the ♀ in its generally smaller measurements, in the conically rounded character of the last abdominal segment, and in the presence of a pair of clasping spines at the junction of trochanter and femur on the inner side of the second pair of legs.

The inner face of the claws in both sexes shows a peculiar empodial modification, consisting of a transparent membranous expansion, of the general shape of the claw itself, extending almost to the apex of the claw and projecting ventrally from it.

Measurements in millimetres.

	♂		♀	
	Length	Breadth	Length	Breadth
Head	0·252	0·420	0·252	0·437
Prothorax ...	0·202	0·395	0·210	0·420
Mesothorax ...	0·040	0·269	0·050	0·302
Metathorax ...	0·185	0·386	0·200	0·420
Abdomen ...	1·001	0·790	1·126	0·890
Total length and greatest breadth	1·680	0·790	1·838	0·890

From a wallaby, *Macropus ualabatus*, Victoria, Le Souëf collection.

The species falls into a small group within the genus characterised by the occurrence of spines upon the dorsal occipital margin. From the two other species of this group with which we are acquainted, *B. grandis* Piaget and an undescribed form, the present species may be distinguished by the simple, not double, eye, and by the absence of a spine in the metathoracic angle.

Genus *Heterodoxus* Le Souëf and Bullen.

Le Souëf and Bullen (1902, p. 159) established this genus for a parasite of "kangaroos and wallabies." Their type species, *H. macropus*, was shown by us (1912, p. 13) to be identical with the *Menopon longitarsus* of Piaget, a fact subsequently pointed out independently by Cummings (1913, p. 44) and Paine (1912, p. 360). Neumann (1912, p. 359) included *H. longitarsus* in his sub-genus *Menacanthus*; but subsequently (1913, p. 634) acquiesced in the generic distinction of *Heterodoxus*.

Heterodoxus is distinguished from *Boopia* by the presence of spines on the under side of the head; by the absence of a post-ocular emargination, and by the acutely rounded temporal lobes.

Several species have been described, all of which must, for the present, be referred to *H. longitarsus*, under which species they are discussed below. In addition to these, we are acquainted with two new species, which will be described in a later communication, both from marsupials, and with a third, which is described below.

Heterodoxus longitarsus [Piaget] Johnston and Harrison.
Figs. 10–11.

Menopon longitarsus Piaget, 1880, p. 504, Pl. 41, fig. 7.
Menopon spiniger Enderlein, 1909, p. 80.
Menacanthus longitarsus Neumann, 1912, p. 359, fig. 5.
Menacanthus spinigerum [Enderlein] Neumann, 1912, p. 364, fig. 12.
Heterodoxus macropus Le Souëf and Bullen, 1902, p. 159, fig. 11.
Heterodoxus armiferus Paine, 1912, p. 362.

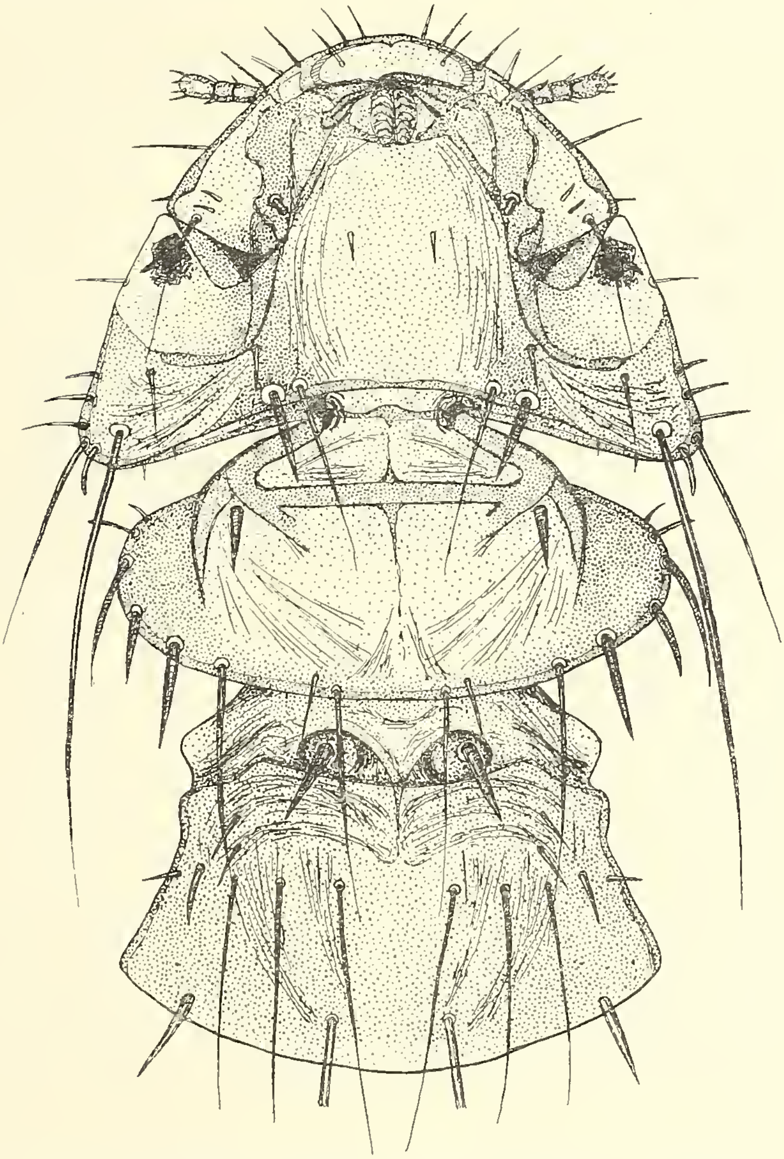

Fig. 10. *Heterodoxus longitarsus,* head and thorax. (L. H *del.*)

We find this species to be generally distributed upon the genus *Macropus.* Piaget originally described it from *Macropus giganteus* in the Rotterdam Zoo. We have it from the following hosts: *Macropus thetidis*, Queensland, N. S. Wales; *M. ualabatus*, Victoria; *M. ruficollis*, Flinders Island; *M. bennetti*, Melbourne Zoological Gardens; *M. dorsalis*, N. S. Wales; *M. rufus*, N. S. Wales; *M. robustus*, N. S. Wales; *M. giganteus*, N. S. Wales, Queensland; *M. wilcoxi*, N. S. Wales; and *M. stigmaticus*, Queensland. It has, in addition, been recorded from dogs from several localities in America and Africa, as well as from Japan; and from a jackal from Africa. This extraordinary host distribution has led Paine (*loc. cit.*) to claim that *Heterodoxus* is "characteristic of dogs." Such is certainly not the case. It is undoubtedly a marsupial parasite, and all occurrences on carnivora must be ascribed to straggling.

The species presents considerable difficulty for the systematic worker, as the range of variation is very considerable. Possibly at a later date characters may be found which will justify a splitting up, but we do not feel inclined to attempt this step at present; for, although forms from certain hosts seem quite distinct if examined alone, intermediate forms can be found upon other hosts, which connect them back with typical *longitarsus.* Curiously enough, the chaetotaxy of the dorsal surface shows a very remarkable uniformity. But we have found great variation, which we thought at first was going to give us characters of diagnostic value, in the chaetotaxy of the thoracic sternites. The variation here, however, finally baffled us. But we would draw attention to these plates, and to the ♂ genitalia, in which we have also observed differences, as likely to afford a solution.

H. armiferus Paine has been included as a synonym, because there is nothing in Paine's description or figures that we allow to have diagnostic value. It is quite possible, however, that this is really a distinct species, and we think it may even prove to be characteristic of some American marsupial host. We have examined the African and Yokohama specimens from dogs, and consider them to be indubitable stragglers from Australian marsupials.

Our figure of the head and thorax is drawn from a typical specimen from *Macropus ualabatus.* The proportions of the head and thorax vary somewhat according to the amount of pressure employed in mounting; a fact which accounts for the minor differences in various published figures.

Heterodoxus brevispinosus n. sp. Fig. 12.

This species is founded upon a single ♀ collected by Mr A. S. Le Souëf from a pouched mouse, *Phascologale flavipes*, at the Sydney Zoological Gardens. We include it for the present within the genus *Heterodoxus*, but its characters lie in some respects intermediate between that genus and *Boopia*, and it may later form the type of a distinct genus.

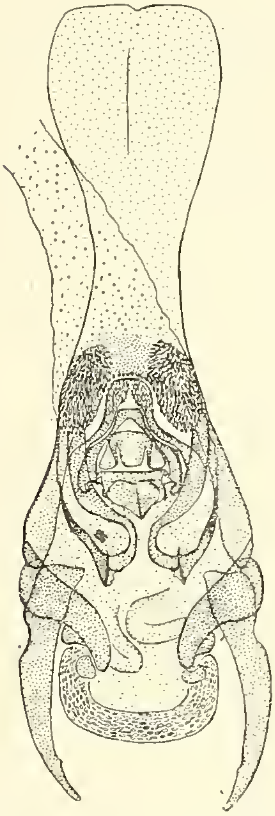

Fig. 11. ♂ genitalia of *Heterodoxus longitarsus* from *Macropus wilcoxi*. (L. H. *del.*)

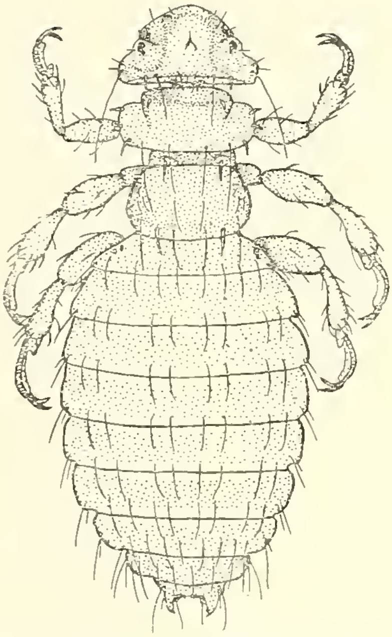

Fig. 12. *Heterodoxus brevispinosus*, ♀. (L. H. *del.*)

Description of ♀. Head almost twice as wide as long, roughly hemispherical in shape, with temporal lobes showing a slight truncation with two rounded angles, a condition intermediate between *Heterodoxus* and *Boopia*. The eye is prominent, with a large pigment fleck and a very short thick spine; and is followed by a very slight emargination, in the angle of which is a short prickle. The occiput carries a pair of stout spines externally, and between them two pairs of hairs, the outer reaching to half the length of the prothorax, the inner very fine and short. The prothorax is almost as wide as the head, somewhat angulated, carrying three curved spines on each wing, and a row of four hairs of even length on the hind margin. The mesothorax is short and narrow, with the usual spines. The metathorax is narrow anteriorly, but widens considerably posteriorly, and is broadly rounded on the abdomen. It carries a few fine hairs in each antero-lateral area, a row of four longish hairs about the middle of its length, and a row of six close to the hind margin, of which the outer pair are long, the next short and spinous, and the median pair shorter, but stouter, than the outer pair. The abdomen is broadly ovate, and exhibits the characteristic form and chaetotaxy of *Boopia*.

The spines upon the under side of the head, which have been mainly instrumental in inducing us to include the species in the genus *Heterodoxus*, are very short, and are not situated at the base of the palps, as in the latter genus, but on the chitinous framework which supports the palps, at the level of the eyes.

Measurements in millimetres.

	♀	
	Length	Breadth
Head	0·206	0·386
Prothorax ...	0·170	0·375
Mesothorax ...	0·054	0·206
Metathorax ...	0·189	0·353
Abdomen ...	0·960	0·756
Total length and greatest breadth	1·579	0·756

Genus *Paraheterodoxus* n.

Characters of the genus. In many respects intermediate between *Boopia* and *Heterodoxus*. General appearance that of *Heterodoxus*, with acutely rounded temporal angles, produced behind the occiput, and a very slight post-ocular emargination. A strong chitinous bar crosses the head dorsally, above the mandibles and bases of the palps, as in *Boopia*. On the under side of the head a pair of stout spines, not at the base of the palps, as in *Hetcrodoxus*, but posteriorly, on the gular margin. Thorax as in *Heterodoxus*, but with hind margin of prothorax angulated, not evenly rounded; and with sinuous lateral margins to the metathorax. Legs, especially the third pair, very strong, and beset with spines. The post-axial margin of the second femur of the ♂ exhibits a special feature in the shape of two closely apposed strong spines, which probably subserve a clasping function. A large form, thickly clothed with spinous hairs. Characteristic of the rat-kangaroos, *Aepyprymnus* spp.

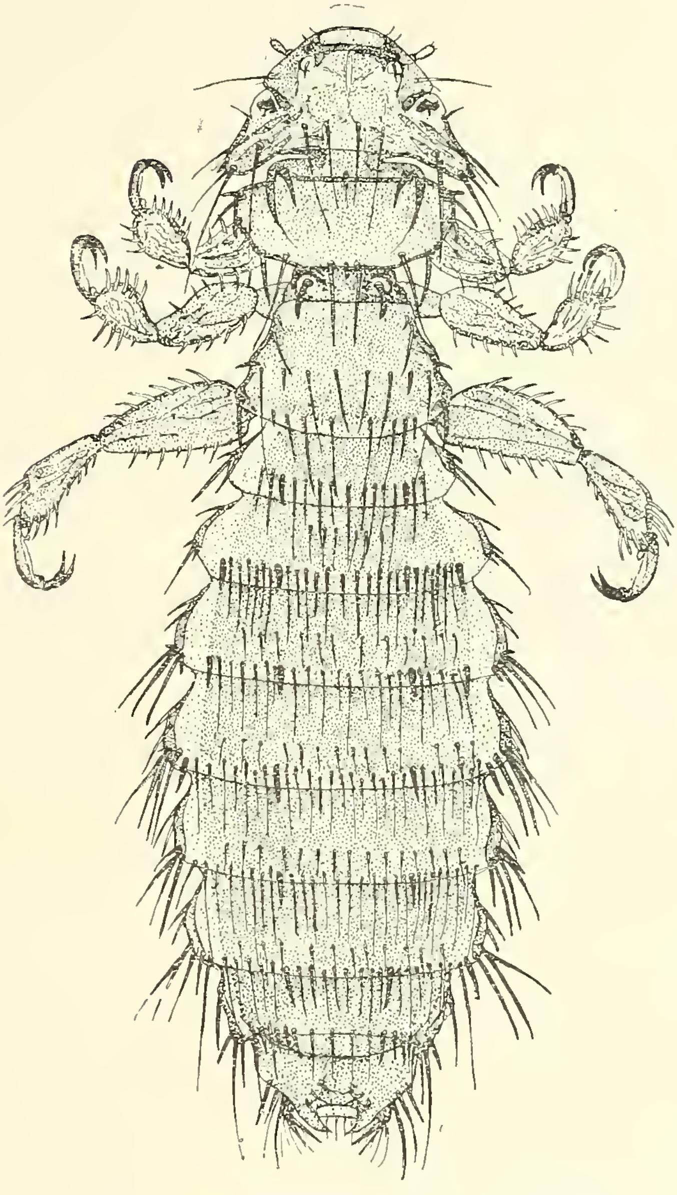

Fig. 13. *Paraheterodoxus insignis*, ♀. (L. H. *del.*)

Paraheterodoxus insignis n. sp. Figs. 13–14.

Description of ♀. Head about twice as broad as long, parabolic in front, slightly emarginate behind the eyes, which form flat projections, and produced behind the occiput into acutely rounded temporal lobes. Prothorax resembling *Heterodoxus*, but angulated, not evenly rounded; equal in length to the head, but slightly narrower. Mesothorax a third as long as the prothorax, with the dorsal prominences widely separate. Metathorax a little longer than the prothorax, but narrower, with slight rounded projections from the lateral margins, carrying a spine, at a little more than half its length. Abdomen almost twice as long as head and thorax together, elongate ovate, widest at the fourth segment, deeply emarginate between segments. Terminal segment ending in two pairs of gonopodial processes, the ventral pair furnished with a couple of spines and some hairs, the dorsal terminating in a short bristle. Legs stout and spinous, with very short first tarsal joint. The hump on the third tibia is rather exaggerated in the figure.

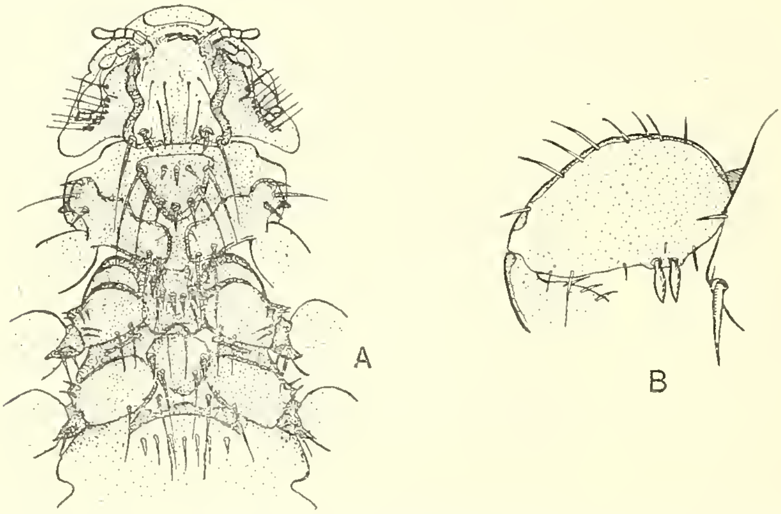

Fig. 14. *Paraheterodoxus insignis.* (A) Under side of head and thorax, ♀; (B) Second femur, ♂. (L. H. *del.*)

Chaetotaxy. A few short hairs on the clypeal margin, a long hair before and a short one behind the eye; a group of longish hairs on the temporal lobe, and four evenly spaced hairs, the outer longer, in front of occiput. The hairs of the thorax, both dorsal and ventral, are sufficiently indicated in the figures. Abdomen with a double row of hairs on segments 2–6, the marginal row of the first seven segments having a pair of spines interpolated at rather less than a third from the lateral margins.

The male differs only in its slightly smaller size, in the previously mentioned clasping spines upon the second femora, and in the posterior end of the abdomen, which is rounded.

Measurements in millimetres.

	♂		♀	
	Length	Breadth	Length	Breadth
Head	0·353	0·706	0·370	0·756
Prothorax ...	0·302	0·638	0·319	0·670
Mesothorax ...	0·100	0·454	0·134	0·538
Metathorax ...	0·365	0·645	0·370	0·706
Abdomen ...	1·636	1·042	2·083	1·193
Total length and greatest breadth	2·756	1·042	3·276	1·193

From *Aepyprymnus rufescens*, N. S. Wales and Queensland. The young differ from the adults in having a much deeper post-ocular emargination, and are likely to be taken for *Boopia*, from which genus, however, they are easily distinguished by the form of the temporal lobes.

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SOME ASCARIDS IN THE BRITISH MUSEUM (NATURAL HISTORY)[1].

By H. A. BAYLIS, B.A. (Oxon.).

(With Plates XIV—XVII.)

1. Ascaris [= "Agamonema"] capsularia *Rud. and its probable adult form,* Ascaris decipiens *Krabbe.*

An examination of a considerable number of specimens of larval Ascarids from the peritoneal tissues of marine fishes has led me to the conclusion that the great majority of these young nematodes are referable to a single species, *Ascaris capsularia* Rud. The older descriptions of this form are inadequate and superficial, and even by the more recent writers it appears to have been assumed that, as a larval form, it was impossible, or not worth while, to define it more precisely. I believe, however, that by paying attention to the internal structure it is possible, even at this early stage, to discover characters of specific importance. The imperfect recognition of these characters has led, it appears, to considerable confusion, and to the inclusion in the species of some forms which should be regarded as specifically distinct. A full synonymy and bibliography has been given by Stossich (1896, pp. 55–57) and it is unnecessary here to review the literature in detail. It is desirable to point out, however, that some even of the comparatively recent descriptions intended to refer to *A. capsularia* seem, in reality, to belong to some other form. Thus É. Blanchard (1849) describes and figures under the name of *A. salaris* a small form, 20–35 mm. in length, having three lips already visible, a lateral caecum at the base of the oesophagus and female genital organs already developed. *A. capsularia* Rud. is included by the author in his synonymy of this form. Von Linstow (1878) describes a similar form, 20 mm. long, which in several respects seems to agree with the specimens that I have examined, but differs markedly from them in having both a forwardly and a backwardly directed caecum; these are said to spring from the second or "glandular" division of the oesophagus. Pavoni, again (1906), has given an account, with figures, of a form which he calls "*Ascaris capsularia.*" His specimens measured only 10–20 mm. in length, and the younger individuals had two well-developed intestinal appendages, *viz.* a shorter dorsal and a much longer ventral caecum. In one example only 12 mm. long, there was no longer any sign of a boring-tooth, the lips were already distinct, and ovaries and uterine tubes were visible. Although this is mentioned as an instance of exceptional and precocious development in a larval form, it seems more probable that Pavoni was dealing with some much smaller species than *A. capsularia,* and that his specimens were already becoming adult. In any case all the three accounts cited seem clearly to refer to some form other than that which I have studied, and which I can only regard as the true "*A. capsularia*"; and doubtless a critical examination of some of the other forms recorded under this name would show that they were similarly misdetermined.

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[1] Published by permission of the Trustees of the British Museum.

Stewart (1906) has given what appears to be a reliable, though brief, account of the true *A. capsularia,* although admitting that the determination of his material is open to doubt. He has paid particular attention to the ventral excretory gland, which is a conspicuous and characteristic structure in this species.

Stiles and Hassall (1899) include in their account of *Ascaris decipiens* some remarks upon certain immature forms also found in seals. They state that these forms agree essentially with the various descriptions of "*A. capsularia,*" and with encysted specimens found in certain fishes, but do not attempt to define at all clearly what is, and what is not, the true *A. capsularia,* or to give a complete account of the anatomy of the larval forms seen by them. They express the opinion, however, that some of the encysted forms found in fishes probably represent the young stages of *A. decipiens,* and cite as probable intermediate hosts the Alaskan pollock (*Theragra chalcogramma*) and the Pacific cod (*Gadus macrocephalus*), both fishes upon which fur seals are known to feed, and in both of which the larval nematodes were found.

Ascaris capsularia *Rud.* s.s.

(Pl. XIV, figs. 1–3; Pl. XVI, figs. 1–2.)

RUDOLPHI (1802), p. 27.
DIESING (1851), p. 163. Also *Agamonema capsularia*, p. 116.
BAIRD (1853), p. 22.
For other literature and synonymy, see STOSSICH (1896).

A number of immature Ascarids in the British Museum collection, bearing various determinations on the labels, have been examined and critically compared with a view to arriving at a clearer conception of their real status. The result of this investigation is that the majority of the immature forms from fishes are found to be referable to the same abundant species; some have been correctly named *Ascaris* (or *Agamonema*) *capsularia*, others under names such as *Agamonema commune* should be included under *A. capsularia*, while others, again, though labelled *capsularia*, should be set aside as incorrectly determined and probably belonging to one or another distinct species. The majority may unquestionably be referred to the true *A. capsularia*, and the following is an attempt to describe that so-called "species" with a somewhat greater degree of precision than has hitherto been done.

The specimens vary from about 9–38 mm. in length, and from 0·22–1·0 mm. in maximum thickness. (Care must be taken with these encysted forms to distinguish between the actual outline of the worm itself and that of the one or more cast-off cuticles which generally surround it. These are not reckoned in the above given measurements of thickness.)

The cuticle is, for the most part, smooth. Near the tail-end, however, it is usually marked with fine transverse striations, the distance between which varies with the age of the individual. In the younger stages the mouth appears to be occluded by the cuticle. The extremity of the head (Pl. XVI, fig. 1) is provided with a conical boring-tooth (*T.*), situated in the position subsequently occupied by the left ventro-lateral lip, and usually bent strongly towards the ventral side. The three lips are at first scarcely visible, or can only be distinguished very vaguely beneath the cuticle of the head. At a later stage the boring-tooth becomes greatly reduced in size in proportion to the lips, which are more readily seen. None of the stages found in fishes, however, exhibit any structure of the lips which enables them to be definitely referred to any one adult species.

The posterior end of the body is thicker than the anterior, and does not taper so gradually. The tail (Pl. XVI, fig. 2) is short, and rounded behind, except for a small tail-spike at the extreme tip. In a specimen 9 mm. long, the tail (*i.e.* the portion of the body behind the anus, including the terminal spike) measured 0·09 mm. In another, about 15 mm. long, the tail measured 0·15 mm. It thus measures about $\frac{1}{100}$ of the total length of the body. In the two cases quoted the tail-spike measured 0·020 mm. and 0·025 mm. respectively. The cuticle of the tail-spike is generally transversely wrinkled, its appearance suggesting that it is capable of a certain amount of extension or contraction.

The alimentary canal (Pl. XIV, figs. 1–3) provides the most satisfactory specific characters, and it is to this that I wish to draw special attention. The oesophagus is divided transversely into two portions of quite different appearance. Anteriorly (*Oes.*^{1}) it possesses the usual thick muscular walls and narrow lumen characteristic of nematodes in general. This portion measures from about $\frac{1}{9}$ to $\frac{1}{12}$ of the total length of the worm; that is to say, it is longer, proportionally to the body, in the younger individuals than in the older. Thus in a specimen 9 mm. long the length of this part of the oesophagus is 1·026 mm. In a 15 mm. example it measures 2·16 mm.; in another of 28 mm., 2·43 mm., and in an older specimen, 38 mm. long, 3·24 mm. This portion of the oesophagus is gradually but slightly thickened towards its hinder end.

The posterior division (*Oes.*^{2}) of the oesophagus is a somewhat oblong organ with very thick walls of granular appearance, which are very opaque even after clearing in creosote. Von Linstow has considered this organ to be of glandular nature, calling it a "Drüsenkörper," and has given a figure of it (1884, Pl. VII, fig. 5, *b*), which, however, gives only a somewhat vague idea of its appearance. In the specimens that I have studied it appears evenly granular, and I have been unable to distinguish cell-boundaries or nuclei in its walls. It extends somewhat further back on the ventral than on the dorsal side. There is probably a narrow passage through it connecting the anterior portion of the oesophagus with the chyle-intestine, though it sometimes appears almost solid. It measures, in an example of 9 mm., 0·38 mm. in length; in a 15 mm. example, 1 mm.; in a 28 mm. specimen, 1·2 mm.; in one of 38 mm., 1·2 mm. It is evident, therefore, that it does not continue to increase in size in proportion to the growth of the individual.

The chyle-intestine (*Int.*), in the youngest examples studied (9 mm.), appears solid, and is composed of large polyhedral cells which become perfectly transparent and colourless when the specimen is immersed in creosote. In the older examples, from 28–38 mm. in length, it acquires a more distinct lumen, its walls at the same time becoming much more opaque and granular, and usually of a rather dark brown colour, so that the worm, when cleared in creosote, appears brown to the naked eye.

In examples under 28 mm. in length, there is no indication (Fig. 3) of any caeca or diverticula springing from any portion of the alimentary canal[1].

In one specimen of about 28 mm. in length (Pl. XIV, fig. 2), a caecum (*C.*) was beginning to spring from the anterior end of the chyle-intestine, in a forward direction, dorsally to the second portion of the oesophagus. In all examples of *A. capsularia*, from about this size upwards, such a caecum is present. It is short at first, but when the worm has reached a length of 38–40 mm. it has grown forward until it is nearly equal in length to the second division of the oesophagus (Pl. XIV, fig. 3, *C.*), round which it fits rather closely, having a concavity on its inner side. It has a moderately large lumen, and opens into the chyle-intestine just behind its junction with the oesophagus.

In no case have I observed any backwardly-directed diverticulum, the dorsal intestinal caecum described being apparently the only appendage present, at least during the larval period. In examining creosote-cleared specimens one is apt to fall into the error of mistaking the posterior rounded end of the granular oesophageal organ, on the ventral side, for a diverticulum; but the careful study of a number of specimens shows that no caecum is really present in this position.

There is a highly characteristic excretory gland on the ventral side of the anterior part of the body; this is present at all stages seen, and has the form of a single, flattened, ribbon-like cell extending throughout (roughly) the anterior third[2] of the body, and containing a very narrow lumen with frequent lateral branches.

Anteriorly, from just behind the thickened posterior portion of the oesophagus, the giant excretory cell becomes much narrower, and its duct runs forward in close connection with the mid-ventral line of the body-wall, to open between the two rudimentary ventro-lateral lips (Pl. XVI, fig. 1, *E.*). This organ has been fully described by Stewart (1906), who has carefully studied its histological nature. It is unnecessary, therefore, to dwell upon it here, except to point out that it is a prominent characteristic of the species, and occurs not only in the larvae, but in the adult *Ascaris decipiens*. Von Linstow (1884) seems to have confused this excretory gland of *A. capsularia* with the "Drüsenschläuche" or "Blinddärmer," of which he says (erroneously, in my opinion) there are two. His figure (Pl. VII, fig. 5, *d*, *e*) seems to show clearly that what he saw was the excretory cell.

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[1] This is in entire disagreement with some of the published descriptions purporting to refer to *A. capsularia*; in some of these descriptions two diverticula are said to have been seen in examples only 10–20 mm. in length. I have seen some specimens of a form only 12 mm. long, from *Gadus callarias*, in which there were two well-developed caeca, but the second portion of the oesophagus, characteristic of the true *A. capsularia*, was wanting, and these specimens must certainly be regarded as belonging to a distinct species. In all probability it was this or some similar form which was seen by the authors of the descriptions referred to, and not the real *A. capsularia*.

[2] Not as much as six-tenths, as stated by Stewart.

I have not observed any indication of the development of genital organs in any of the larval stages examined.

The larvae undergo at least two ecdyses within their surrounding capsules, which are presumably formed by a morbid hypertrophy of the peritoneal tissues of the host. The cast-off cuticles are not completely got rid of by the larva until it is liberated from the capsule, but expand so as to form an additional loose protective sheath or sheaths, one within the other, and permit of the continued growth of the larva within them.

Ascaris decipiens *Krabbe.*

(Pl. XIV, fig. 4; Pl. XV, fig. 1; Pl. XVI, figs. 3–4.)

Krabbe (1878), p. 45; Pl. I, fig. 3.
Jägerskiöld (1894), p. 467; Pl. XXV, fig. 14; Pl. XXVI, fig. 26; Pl. XXVIII, figs. 40, 41.
Stiles and Hassall (1899), p. 109; Figs. 1–19.
Ascaris simplex, von Linstow (1888), p. 2; Pl. I, figs. 1–4.

The present observations on the adult form are based upon a re-examination of specimens from *Otaria jubata* obtained at Kerguelen by the *Challenger*, and determined by von Linstow as *Ascaris simplex* Rud. This seems to have been a misdetermination, though it is difficult to understand how so experienced a helminthologist was led to make the error. At that time, however, the description of *A. decipiens* given by Krabbe was the only reliable and at all detailed account available, and the characters of the lips, alimentary canal and other important systematic points had not been so accurately figured and described as has now been done, owing to the careful work of the later authors.

It will be necessary to give a brief redescription of the *Challenger* specimens in order to substantiate the new determination; and this will, it is hoped, at the same time give further support to the view that *A. decipiens* is the adult form of the true "*A. capsularia.*"

The male (of which there is now only one example) is 50 mm. in length, and 2 mm. in thickness. The females measure 67–90 mm. in length, and 2–2·5 mm. in thickness. The cuticle, quite smooth to the naked eye, is seen under the microscope to be marked with minute transverse striations only $2{\cdot}5\,\mu$ apart, and thrown into larger wrinkles at about every thirteenth striation, but somewhat irregularly. At about 0·7 mm. from the anterior end there is a pair of rather large, conical cervical papillae.

The lips (Pl. XVI, fig. 3) conform much more closely to Krabbe's figure of the lip of *A. decipiens* (1878, Pl. I, fig. 3) than to that of *A. simplex* (*l.c.* Fig. 4). I am at a loss to understand how, with the *Challenger* material before him, von Linstow was led to make his figure (1888, Pl. I, fig. 2) so nearly a copy of Krabbe's figure of *A. simplex.* I also find the closest agreement between the shape of the lips in the *Challenger* specimens and that shown in the original drawings of *A. decipiens* given by Stiles and Hassall (1899, Figs. 10–14). The anterior, bilobed portion of each lip spreads out laterally at each corner in precisely the manner figured by Krabbe and the American authors, and is of quite a different shape from that of *A. simplex.* The dorsal lip is more upright, when seen from the anterior aspect, than the two ventro-lateral lips, and its bilobed portion has a more distinct "neck." The bilobed portion of the dorsal lip is slightly narrower than that of the other lips (0·19 mm. < 0·21 mm.), but the basal part is actually broader (0·28 mm. > 0·25 mm.). From the measurements given by von Linstow it would seem that he must have mistaken the "neck" of the bilobed portion of the dorsal lip for its basal part; an error that might easily occur when viewing the lips in optical section. The width of this "neck" is about 0·13 mm. A dentigerous ridge is present near the edge of each lip, as stated by all the authors. There are no interlabia.

The tail of the male (Pl. XVII, fig. 2) is considerably widened out laterally, the widest part being about 3 mm. from the tip of the tail. The edges are prominent muscular ridges rather than cuticular alae, and are normally drawn inwards towards the mid-ventral line, so that a transverse section in this region of the body would show a concavity on the ventral side. For rather less than 1 mm. from the tip, the tail is bordered by membranous lateral alae (*A.*), forming a three-lobed bursa, which, when the tail is curled ventrally in the usual manner, becomes a cup-shaped hollow. The tail-papillae are arranged in essentially the pattern described by Krabbe and by Stiles and Hassall. In the single male example available, however, I have been unable to distinguish the three symmetrically arranged pairs of papillae immediately behind the anus. An irregular row of about 60 papillae extends forward along the lateral ridge on each side, to a distance of 6–7 mm. from the tip of the tail. The spicules (*S.*) are tubular, about 2 mm. in length and slightly expanded at their proximal ends.

In the female, the anus is situated in a transverse fold of the cuticle at about 0·3 mm. from the tip of the tail. The latter (Pl. XV, fig. 1) is blunt, and shows a little indentation (0·1 mm.) of the cuticle at the extreme tip, but there is no styliform process embedded in the cuticle, as stated by von Linstow. The vulva, in an example 70 mm. long, is situated at 26 mm. from the anterior end. The uterus (Pl. XVI, fig. 4, *Ut.*) in the same specimen, measures altogether 38 mm. in length. Its undivided anterior portion, *i.e.* from the vulva to the point of division into the two posterior horns, measures 24 mm., while the horns measure 14 mm. The whole organ is nearly straight and without convolutions, except near the vulva.

As in the case of the larval form, so again in the adult, the alimentary canal (Pl. XIV, fig. 4) affords very useful specific characters; and the correspondence between the young and adult forms in this respect, except with regard to the relative sizes of the several parts of the digestive apparatus, is most complete and satisfactory.

The oesophagus shows the same division into two portions, an anterior muscular part (the oesophagus proper), and a posterior part with thickened, opaque, granular walls. The former measures 3·6–3·8 mm. in length, the latter about 1·35 mm. These measurements are in accordance with what might be expected from those of the same organs in the larval forms. The two parts of the oesophagus have increased slightly in length, but not proportionately to the general growth of the body. The posterior portion is bent so as to open into the intestine almost at a right angle.

There is an anterior caecal prolongation of the chyle-intestine, exactly similar to that seen in the larvae; it has now, however, increased considerably in length, so that it is about $\frac{1}{3}$ as long again as the second portion of the oesophagus, and projects some little distance in front of it (Pl. XIV, fig. 4, *C.*). Its extremity is attached by a ligament to the body-wall on the dorsal side. I have not seen an instance of the presence of a backwardly-directed oesophageal caecum, although Jägerskiöld (1894) and Stiles and Hassall (1899) have both stated that such a caecum is occasionally present, and have figured examples of it.

The ventral excretory gland exhibits essentially the same features as in the larval forms, being a flattened, ribbon-like cell lying along the inside of the body-wall for about the anterior third of the body. At its widest part it measures slightly more than 1 mm. At the level of the junction between the oesophagus and chyle-intestine, and the base of the intestinal caecum, it narrows rather rapidly, but still runs forward quite distinct from the body-wall. Its duct merges with the mid-ventral "field" of the latter at about 1 mm. from the head-end, opening, as described by Stiles and Hassall, between the ventro-lateral lips.

Systematic Position.

In their preliminary report on the Parasitic Worms of the *Terra Nova* Expedition, Leiper and Atkinson (1914, p. 226) have instituted a new genus, *Terranova*, for an Ascarid from the stomach of a shark.

The following features mentioned in the diagnosis of the type-species, *Terranova antarctica* (1914, p. 226; 1915, p. 28) are of interest in connection with *Ascaris decipiens*: "Three squat fleshy lips with paired anterior lobes. No labia intermedia. Oesophagus without appendage. The intestine has a long caecum." Further, the oesophagus "enters the intestine laterally," though no mention is made of a specialized posterior division similar to that seen in *A. decipiens*. The excretory organ is not mentioned. The authors do not attempt to include any of the previously-described species of *Ascaris* in this new genus; but they have created another, *Kathleena* (1914, p. 226), in which they include (1915, p. 27) "*Ascaris*" *osculata* Rud., "*A.*" *radiata* v. Linst., and "*A.*" *rectangula* v. Linst. This genus differs from *Terranova* chiefly in having interlabia and a solid oesophageal appendage.

If the anatomical features mentioned are to be considered sufficient grounds for the separation of these two genera from each other, and from *Ascaris* itself, it would seem likely that *Ascaris decipiens* will have to be included in *Terranova*. But probably it will be found that other species of *Ascaris* agree with one or the other of the new genera, and the re-examination of such forms would throw much light on the question. For the present, at all events, I prefer not to press the point, but rather to retain the older generic name for *Ascaris decipiens*.

Hosts of the larval form, "Ascaris capsularia."

A long list of fishes is given by Stossich (1896, p. 58) as hosts for this "species," but unfortunately it is impossible to decide how many of the cases mentioned by him were really *A. capsularia,* as now defined, and how many represented other immature forms. All that it is possible to do at present, therefore, is to give a list of the fishes from which I have personally examined specimens that conform to the description given above, and which I regard as *A. capsularia, sensu stricto.* These represent, probably, only a very small fraction of the hosts of this apparently abundant and widely-distributed form.

The list is as follows:

Host	Previous determination of parasite[1]
Aphanopus carbo	(1) *A. capsularia* Rud. (2) and (3) *Agamonema commune* Dies.
Clupea alosa	*Agamonema capsularia* Dies.
Clupea harengus	*Ascaris,* sp.
Cottus scorpius	*Ascaris constricta* Rud.
Gadus callarias	*Agamonema commune* Dies.
Lampris luna	None.
Merluccius, sp.	*Agamonema capsularia* ? Dies.
Molva molva	*Agamonema commune* Dies.
Motella mustela	*Ascaris capsularia* Rud.
Pleuronectes flesus	*Ascaris collaris.*
Salmo salar	*Agamonema commune* Dies.
Sciaena aquila	*Ascaris constricta* Rud.
Sebastes norvegicus	None.
Sphyraena, sp.	*Ascaris sphyraenae.*

History of the parasite in its final host.

It seems probable that the stage of development at which the larvae are swallowed, along with their first host (a fish), by their final host (a seal) makes little difference to their subsequent history.

Stiles and Hassall (1899, p. 117) give as the length of the immature forms from the stomach of the fur seal, 14 mm. or more. Von Linstow (1900, p. 119) describes immature forms, which he refers to *A. decipiens,* as living in dense masses in the stomach of the walrus (*Odobenus rosmarus*) and *Phoca barbata.* These larvae measure, according to this author, anything from 5 to 37 mm. in length. They have their heads embedded in the mucous membrane of the stomach, and in this position undergo several ecdyses. When they reach a certain size, he considers, they migrate into the intestine of their host and there become sexually mature.

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[1] It should be understood that I do not imply that all the names under this heading are synonyms of *A. capsularia,* but merely that these various names have been attached to specimens of that form. It is probable that some of the names are synonymous, but in order to prove this it would be necessary to re-examine the types.

As has been remarked already, the larvae seen encysted in fishes are always enclosed within their own cast-off skins. Hence, when the fish is swallowed by a seal, and the worms set free from the cysts, it is clear that they will still have to rid themselves of these old cuticles, and in all probability this does not normally take place except under the influence of the gastric juice of the seal. In this way the account of von Linstow is brought into accordance with the American authors' and my own hypothesis, *viz.* that the seals become infected with this Ascarid through eating fishes containing the encapsuled larvae. With the further supposition that the fishes ingest the eggs of the worm contained in the faeces of the seals, we have a fairly complete idea of the life-history of the parasite. Without the aid of direct infection-experiments with the appropriate hosts, it is impossible to make the conclusion more certain.

A summary of the hosts from which the adult *A. decipiens* has been recorded is given by Stiles and Hassall (1899, p. 109). They are all species of seals. To this list must now be added *Otaria jubata*, which must, at the same time, be removed from the list of hosts for *A. simplex* Rud. This will leave, as properly authenticated hosts of the latter species, only the Cetacea. It seems highly probable that *A. simplex* is restricted to the whales and porpoises, while *A. decipiens* is parasitic, as an adult, only in seals and walruses.

2. *Re-examination of the types of* Ascaris similis *Baird.*

(Pl. XV, fig. 2; Pl. XVII, fig. 1.)

Ascaris similis Baird (1853), p. 19, Pl. I, figs. 1 *a*–1 *e*; Diesing (1860), p. 656; Stossich (1896), p. 69; Stiles and Hassall (1899), p. 146.

Of this form the only description we have is the original diagnosis given by Baird[1], and there appears to have been no record of the occurrence of the worm since 1853. Stiles and Hassall doubt the validity of the species, and suspect that it should be included in *A. decipiens*. With a view to deciding this point, I have undertaken a re-examination of Baird's original material, which is contained in two bottles in the British Museum collection. One bottle is labelled "male," the other "female," but both now contain examples of both sexes. The contents of one bottle are in very poor condition, and I have made use of these only as an aid in following out the tail-papillae of the male, which happen to be easily seen owing to the macerated condition of the internal parts of the worms. The other bottle contains 8 specimens in a very fair state of preservation, and some of these have given good results when treated with creosote.

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[1] This diagnosis is repeated, with only slight verbal changes, in *Proc. Zool. Soc.*, 1853, p. 18; and in *Ann. Mag. Nat. Hist.* (2), xv, (1855), p. 69.

The specimens show several features in which they differ markedly from *A. decipiens*, and I do not think that they can be ascribed to any of the other species of *Ascaris* from seals, of which adequate descriptions have been published. Hence I am inclined to uphold Baird's view that this is a distinct species, and to retain his name for it. His description and figures, however, are so inadequate, according to modern requirements, that it will be advisable to supplement them with a brief new description of the material.

The specimens vary from about 40 to 60 mm. in length, and from 1 to 2 mm. in thickness. The body tapers much more gradually anteriorly than posteriorly, especially in the female.

The cuticle is divided by transverse grooves into bands about 23 μ wide, in each of which there are about ten finer striations.

Contrary to the statement of Baird, there are no prominent lateral alae, except in the male, where they are limited to a very small expansion at the sides of the tail. The lateral fields, however, which measure 0·27 mm. in width, are visible to the naked eye as pale bands, and in all probability Baird mistook these for "wings."

There is a pair of large neck-papillae, situated at about 0·78 mm. from the anterior end.

The lips (Pl. XV, fig. 2) have a characteristic shape, and are quite different from those of *A. decipiens*. The dorsal lip is shorter than the other two, and is more or less crescentic in outline, with a prominent bilobed anterior portion projecting from the middle of its inner, or concave, side. The "pulp" is prolonged into the horns of the "crescent," and also sends two rounded processes into the anterior lobe. There is a pair of double papillae on the convex surface of the "crescent." The two ventro-lateral lips are of a more usual shape, each having a bilobed anterior projection and a large double papilla on the outer surface. The two processes of the "pulp" which extend into the anterior projection of each lip are unequal, that nearer to the mid-ventral line being slightly narrower than its more lateral fellow. The dorsal lip measures 0·24 mm. across at its base, the ventro-lateral lips 0·19 mm. Each of the three lips is provided with a simple dentigerous ridge on its inner side near the anterior end, the teeth being somewhat irregular in size and arrangement.

The oesophagus is divided, as in *A. decipiens* and other related forms, into an anterior muscular portion, and a posterior portion which is opaque and granular in appearance, and possibly glandular in function. The latter portion is frequently bent in the form of an S, as observed by Stiles and Hassall (1899) in the case of *Ascaris typica*. The alimentary canal bears no caeca or diverticula of any kind, differing markedly in this respect from that of *A. decipiens*.

There is a ventral excretory gland, which appears to be precisely similar to that of *A. decipiens*, and opens, in the same way, by a small pore situated between the ventro-lateral lips (Pl. XV, fig. 2, *Ex. P.*).

The tail of the male (Pl. XVII, fig. 1) has normally a strong ventral flexure. It is bordered laterally, at the tip only, by a slight cuticular expansion. The sides of the body do not show the marked expansion in front of the tail, which was observed in *A. decipiens*. There are eleven postanal papillae, *viz.* five pairs, and an unpaired papilla near the extreme tip of the tail. In front of the anus there are sixty or more papillae on either side of the body, extending forwards to about 3·5 mm. from the posterior end. These papillae are placed in a very regular row immediately before the anus, but their arrangement becomes much more irregular on passing forwards, giving an appearance as if two or more rows had been broken up and confused.

The spicules (Pl. XVII, fig. 1) are equal in length (2 mm.) and resemble in shape those of *A. decipiens*.

The tail of the female is even shorter and blunter than that of *A. decipiens*. The anus is situated at 0·2 mm. from the posterior end. The tip of the tail is slightly indented, and without a terminal spike.

The vulva is situated near the middle of the body. In a specimen measuring 48 mm. in total length, it opens at 25 mm. from the anterior end. The uterus and its two posterior horns are proportionally longer and narrower than in *A. decipiens*, and the whole organ is much convoluted. The horns, moreover, instead of being considerably shorter than the undivided portion, are about equal to it in length.

The ova are spherical, and measure 0·04–0·05 mm. in diameter.

The host of this species was a seal from the Antarctic regions, but unfortunately its precise determination is unknown.

3. Ascaris rosmari, *new name* (= Ascaris bicolor *Baird*).

(Pl. XV, fig. 3; Pl. XVII, fig. 3.)

Ascaris bicolor Baird (1868), p. 71, Text-figs. *A–C*; Murie (1868), p. 67; Stiles and Hassall (1899), p. 138, Figs. 52–56 (copied from Baird).
[nec Rudolphi (1793).]

Of this species, as in the case of *A. similis*, the only description at present available is that of Baird, who confined himself to the examination of the external features. Stiles and Hassall examined some of the cotypes, but were unable, from the material they had at their disposal, to do more than add a few details (1899, p. 142). All the specimens seen by them were females.

Baird's original description is very brief, and it may be well to quote it in full:

"Ascaris bicolor *Baird.*

"Head naked; labia distinct, prominent, rounded, and of moderate size. Both anterior and posterior portions destitute of alae or wings. Body of worm cylindrical, attenuated anteriorly, of a brownish colour, except at the anterior extremity, which is white; the posterior extremity is sometimes red. The surface of the body is beautifully and minutely but distinctly striated across; as seen under the microscope (with a power of two-thirds of an inch), the striae on each side terminate in such a manner that the edges of the body appear as if serrated. Caudal extremity thicker than anterior, obtuse, and generally convoluted.

"A great many specimens were found in the stomach [of a walrus]; but apparently all were females.

"The *Ascaris simplex* of Rudolphi, found in the stomach of the porpoise (*Phocaena communis*), very nearly approaches this species in general appearance and size, but differs from it in several respects.

"The *Ascaris bicolor* is *less attenuated* at the anterior extremity than the *A. simplex*, and is *destitute* of alae or wings equally at the *posterior* and at the *anterior* extremity. The striations on the surface of the body are much finer, and the labia or valves at the mouth are more distinct and larger.

"Length from 2½ to 3 inches; breadth from 2 to 2½ mm.

"*Hab.* Stomach of a young male walrus (*Mus. Brit.*)."

The account given by Dr Murie (1868) of the effects of the worm upon its host, is interesting from a pathological point of view, but does not deal with the systematic position or anatomy of the parasite, this being left to Dr Baird, whose diagnosis is appended to Murie's paper.

Stiles and Hassall, after examining some of Baird's material, add the following remarks to Baird's description:

"All of the specimens are females, and on this account we are unable to definitely place the parasites. They are poorly preserved, but we were able to distinguish a dentigerous ridge on the lips; no intermediate lips were present; the cuticular bands measure 24 μ broad, and are *apparently* not provided with any finer striation; the oesophagus resembles the oesophagus described by Jägerskiöld for *A. simplex*, oesophageal and intestinal caeca being absent."

These authors further state that they refrain from proposing a new name for the homonym *A. bicolor* Baird, as they doubt the validity of the species.

Having made a careful re-examination of Baird's original material, which is preserved in two bottles in the British Museum (Natural History), I am now able to give a fuller account of this form, and to substantiate Baird's view that it is a distinct species. In the first place, I find myself in disagreement with the statement of Messrs Stiles and Hassall, that the material is poorly preserved. Both bottles contain a large number of specimens, in a sufficiently good state of preservation for all ordinary purposes. Moreover, contrary to Baird's statement, males are present in fair proportion to the females. I have not, however, observed any with the spicules extended, and the tail of the male is not always closely curled, so that these two facts may perhaps account for the erroneous statement that males were absent. The average size of the females is considerably larger than that of the males, the largest specimen measuring about 9·5 cm. in length. In thickness the specimens (disregarding obviously immature individuals) measure from 1·5 to 2·5 mm. The anterior end is very slender and tapering, the posterior end considerably thicker, until it rather rapidly diminishes towards the tip. The "brownish colour" of the body, mentioned by Baird, is due to the deep colour of the chyle-intestine. Anteriorly, in the oesophageal region, this colour is absent.

The cuticle is very sharply marked out into transverse bands from 25μ to 50μ in width, the posterior edges of the bands projecting in such a way as to present, in a profile view, an appearance much like minute saw teeth, or the hinder angles of the segments of some cestodes. This has been remarked upon by Baird (*vide supra*), but his figure (1868, Fig. B) does not convey the appearance at all clearly. These cuticular bands do not appear to be marked with any finer striations. Lateral alae are absent; the lateral fields measure 0·15 mm. in width. A well-developed pair of neck-papillae is present at about 0·74 mm. from the anterior end.

The lips (Pl. XV, fig. 3) bear a very close resemblance to those of *A. similis*, but are of a slightly different shape. There is the same almost straight dorsal border to the basal portion of the dorsal lip, and a similar narrow, bilobed, anterior projection. The papillae at the outer angles of the dorsal lip are double, like those of the ventro-lateral lips. The greatest breadth of the dorsal lip is 0·24 mm., that of the ventro-lateral lips 0·18 mm. The dentigerous ridges are simple. There are no interlabia.

The oesophagus is, as in the preceding species, divided into two portions. The anterior portion is rather narrow, and about 4–5 mm. long. The posterior portion is usually very slender, not very granular, and measures rather more than 2 mm. in length. It is joined to the chyle-intestine by an oblique suture, and may be either perfectly straight or bent in a sigmoid manner. There is no trace of either oesophageal or intestinal caeca.

The tail of the male (Pl. XVII, fig. 3) is provided with a slight membranous expansion near the tip. In front of this it is expanded laterally and ventrally by a strong muscular ridge on either side, similar to that described above for *A. decipiens*. There are six pairs of postanal papillae. Those of the first pair, situated immediately behind the anus, are small. These are succeeded by a larger, more ventral pair. The third pair are large lateral papillae, projecting into the membranous alae. The fourth and sixth are rather smaller, and project laterally in a similar manner, while the fifth pair is situated a little more ventrally than the fourth and sixth. There is a pair of small papillae situated just laterally to the corners of the anal aperture, and in front of this a row of 50 to 60 papillae on either side of the body, beginning regularly just in front of the anus, but becoming very scattered more anteriorly. These papillae extend forwards to a distance of about 6 mm. from the posterior end.

The spicules are very slender, and measure slightly less than 2 mm. in length.

The tail of the female is short (0·3 mm.) and blunt, and has a blunt terminal papilla. The vulva is situated a little in front of the middle of the body (34 mm. from the anterior end in a specimen 79 mm. long). The unpaired portion of the uterus is extremely short, the division into the two posterior horns occurring at 10 mm. from the vulva. The horns are 18 mm. long, and both these and the unpaired uterus are straight.

The ova are spherical, and measure 0·05 mm. in diameter.

This species has a ribbon-like ventral excretory gland, similar to those of the previously-described forms, and measuring 1 mm. in width. The duct of the gland opens, as in the other cases, by a small pore between the ventro-lateral lips.

This form having now been placed on a more satisfactory basis, as a valid species, it becomes necessary to propose a new name for it. This necessity arises owing to the fact that Rudolphi (1793, p. 13), published the name *Ascaris bicolor* for another worm; and although he subsequently (1809, II. p. 173) changed this name to *Ascaris truncatula*, the original name, according to the law of priority, must stand, and consequently the name *A. bicolor* for Baird's species is preoccupied. It is therefore proposed to substitute the name *Ascaris rosmari*.

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EXPLANATION OF PLATES XIV—XVII.

PLATE XIV.

Fig. 1. *Ascaris capsularia.* Anterior end of a larva 28 mm. long, from *Sebastes norvegicus,* viewed from the left side. *Int.* chyle-intestine; *Oes.*[1] anterior division of oesophagus; *Oes.*[2] posterior division of oesophagus.

Fig. 2. *Ascaris capsularia.* Anterior end of a larva 28 mm. long, from *Sciaena aquila,* showing the beginning of the intestinal caecum (nearly dorsal view). *C.* intestinal caecum; other lettering as in Fig. 1.

Fig. 3. *Ascaris capsularia.* Anterior end of a larva 38 mm. long, from *Sciaena aquila*; nearly dorsal view. Lettering as in Figs. 1 and 2.

Fig. 4. *Ascaris decipiens.* Anterior portion of the alimentary canal. Lettering as in Figs. 1–3.

PLATE XV.

Fig. 1. *Ascaris decipiens.* Tail of the female; ventral view. *A.* anus.

Fig. 2. *Ascaris similis.* The lips, viewed from the front. *D.* dorsal lip; *D.R.* dentigerous ridge; *Ex.P.* excretory pore; *P.* papillae.

Fig. 3. *Ascaris rosmari.* The lips, viewed from the front. *D.* dorsal lip; *Ex.P.* excretory pore; *M.* mouth; *P.* papillae.

PLATE XVI.

Fig. 1. *Ascaris capsularia.* Head of larva 15 mm. long, from *Clupea alosa,* viewed from the right side. *D.* dorsal lip; *E.* excretory pore; *L.V.* left ventro-lateral lip; *Oes.* oesophagus; *R.V.* right ventro-lateral lip; *T.* boring-tooth.

Fig. 2. *Ascaris capsularia.* Tail of larva 15 mm. long, from *Clupea alosa,* viewed from the right side. *A.* anus; *T.Sp.* tail-spike.

Fig. 3. *Ascaris decipiens.* The lips, viewed from the front. *A.L.* anterior lobes; *D.* dorsal lip; *V.* ventro-lateral lips.

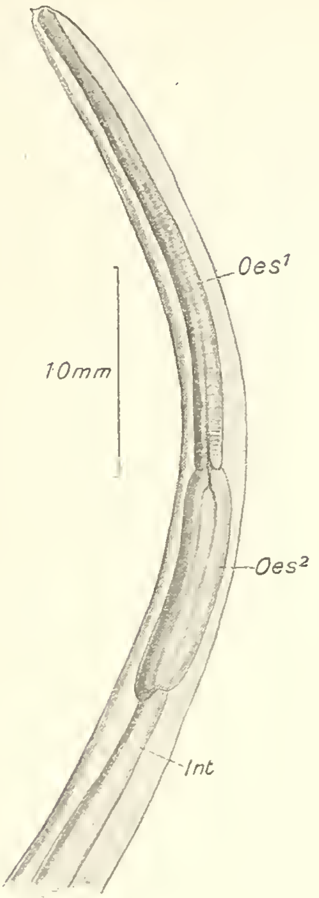
Fig. 4. *Ascaris decipiens.* Portions of the female genital apparatus; × 2. *Ov.* ovarian tubes; *Ut.* uterus; *V.* vulva.

PLATE XVII.

Fig. 1. *Ascaris similis.* Tail of the male; ventral view, showing the spicules, caudal alae and papillae (semi-diagrammatic).

Fig. 2. *Ascaris decipiens.* Tail of the male; ventral view. *A.* caudal alae; *S.* spicules.

Fig. 3. *Ascaris rosmari.* Tail of the male; ventral view, showing the spicules, caudal alae and papillae (semi-diagrammatic).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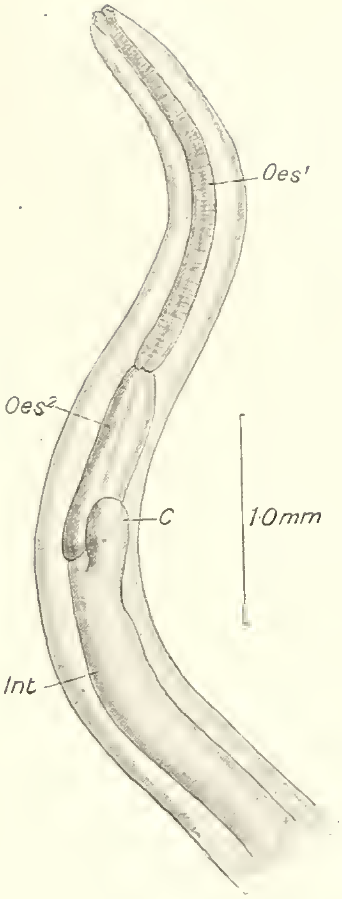
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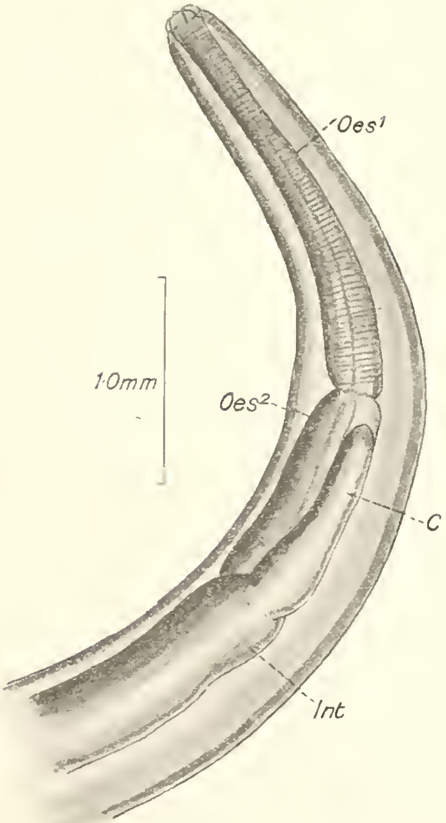
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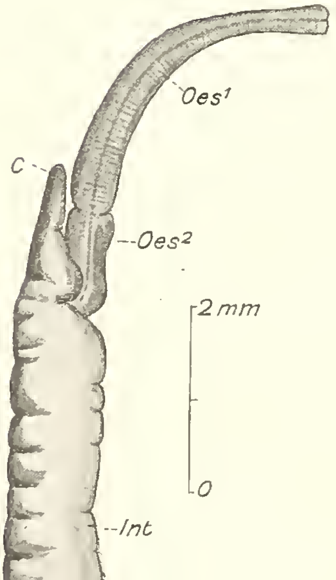
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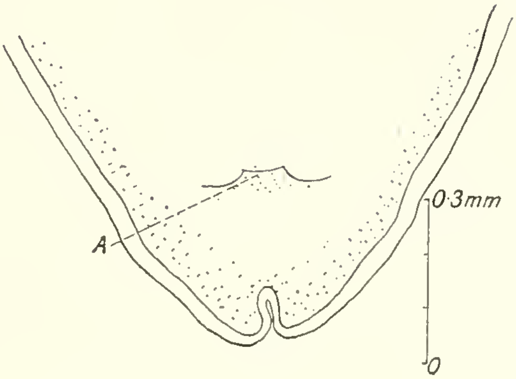

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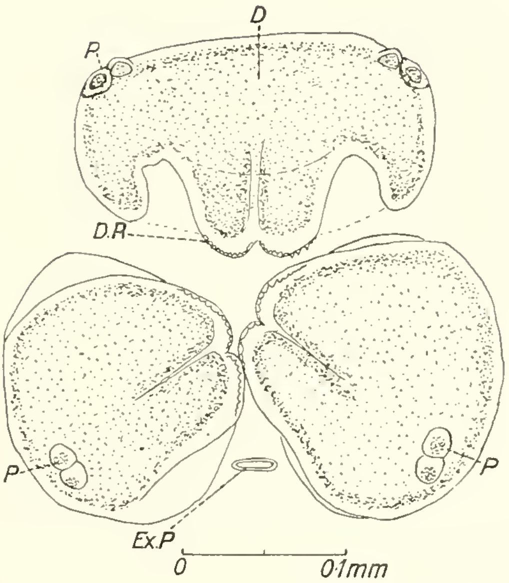

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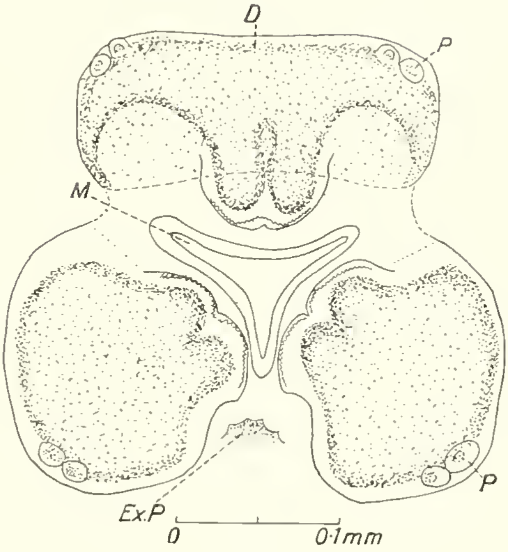

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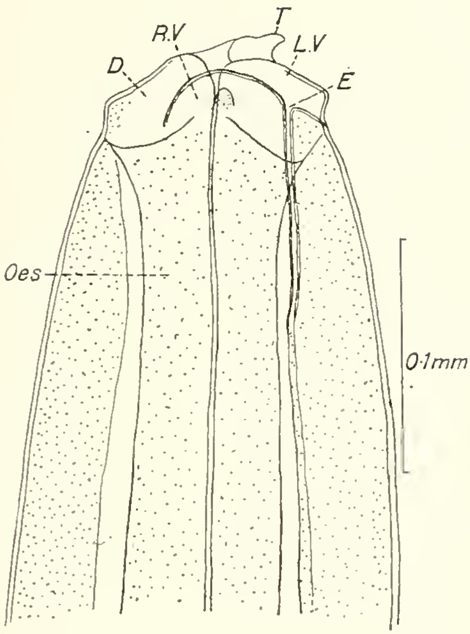

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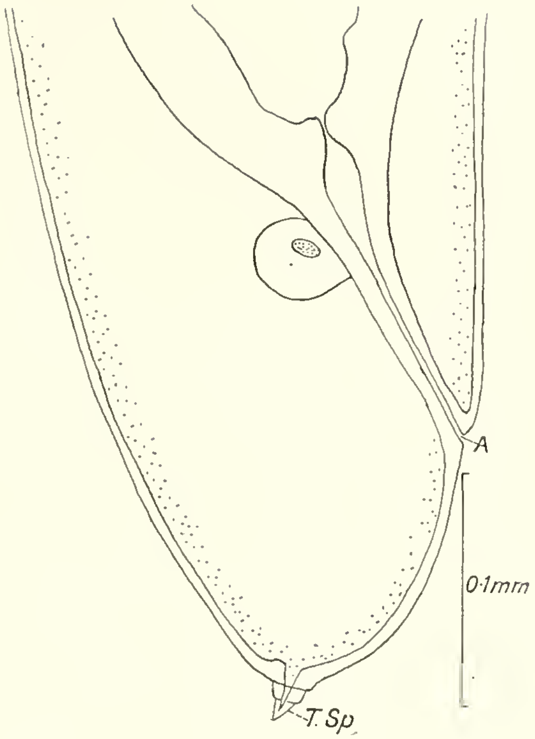

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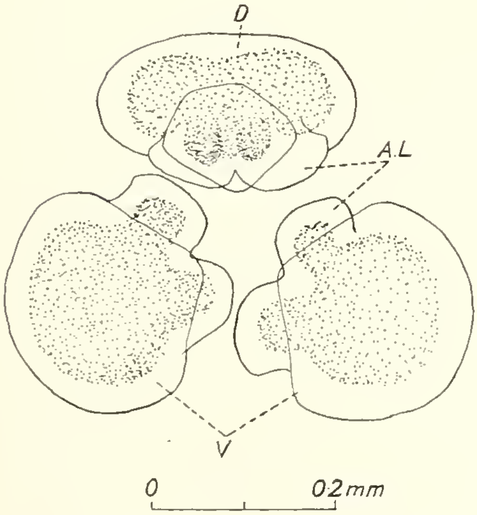

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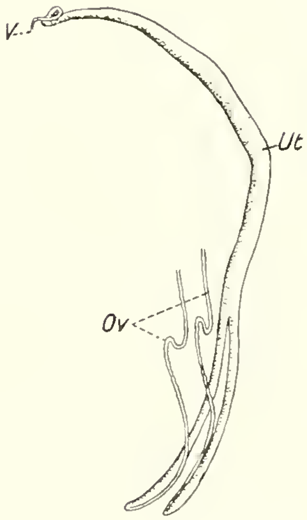

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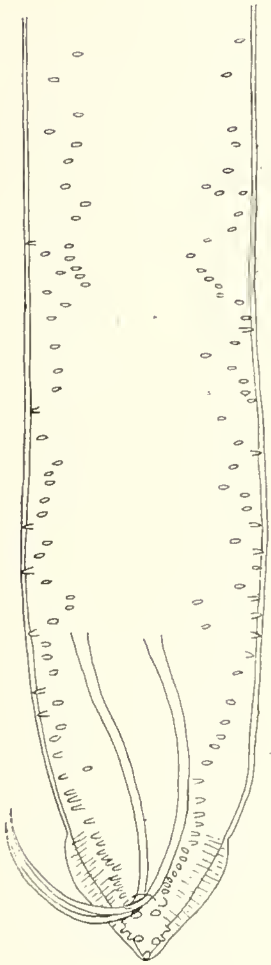
PLATE XVII



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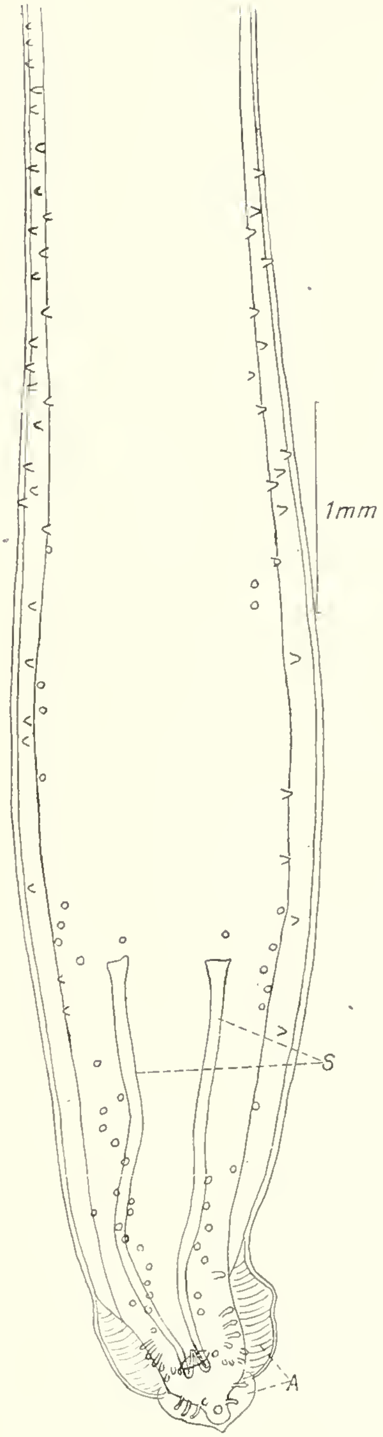

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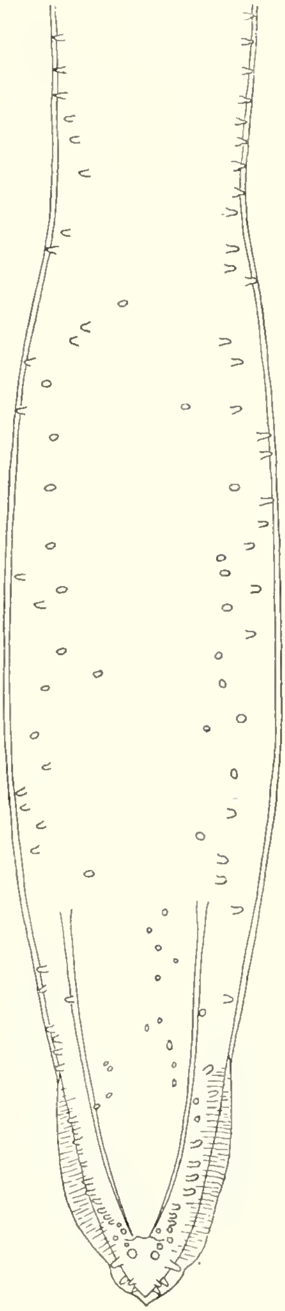

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[The scale refers only to Fig. 2.]

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A REPORT ON RESEARCHES ON SPRUE IN CEYLON

1912—1914

By

P. H. BAHR

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